Sewage Collection Systems

THE VACUUM WAY

An introduction to

Iseki RediVac Vacuum Technology

Iseki Vacuum Systems Limited

This document is intended as a source of information for engineers, developers, contractors and clients interested in learning about the vacuum sewage collection systems designed by Iseki Vacuum Systems Ltd. The information herein is for reference purposes only and readers should not plan or design a vacuum sewerage system based upon the information contained within this publication without prior consultation with Iseki Vacuum Systems Limited.

Iseki Vacuum Systems Limited have a continuous research and development programme for their vacuum sewage collection systems and reserve the right to change the equipment, material specifications and design parameters of their vacuum systems without notice.

For further information on Iseki's vacuum technology please use the contact details given below:

Iseki Vacuum Systems Limited
High March
Daventry
Northamptonshire
NN11 4QE
United Kingdom

Tel : + 44 (0)1327 878777
Fax : + 44 (0)1327 315232
Website: www.iseki-vacuum.com
E-mail : sales@iseki-vacuum.com

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SECTION 1

INTRODUCTION

Iseki Vacuum Systems Limited (trading as Iseki RediVac) is based in Daventry in the United Kingdom from where it markets its vacuum technology world-wide through local representatives and distributors. This UK office provides the expertise required for developing and supporting this technology throughout its world-wide markets.

This engineering expertise has been developed over the past 10 years and during this time Iseki RediVac's engineers have gained a wide understanding of the potential uses of their vacuum systems and have applied this experience to many different applications.

With a broad staff base covering many disciplines, Iseki RediVac is able to offer clients services which range from initial project appraisals through to commissioning and handover of their vacuum systems.

Iseki RediVac believes strongly in customer support and is able to offer technical advice and assistance to local operators of their systems and, if required, on-site supervision from one of their own field engineers.

To supplement this, Iseki RediVac has a network of service centres across the world providing local support to system operators.

The key item of equipment within any vacuum system is the vacuum interface valve housed within the collection chambers. Iseki RediVac's interface valve has been in use for more than 10 years and during that time has seen a number of improvements to further enhance its performance and reliability.

These performance capabilities were demonstrated through tests which required the valves to operate in excess of 250,000 times which is the equivalent of more than 15 years of normal operation.

The successful completion of these tests resulted in Iseki RediVac's valve complying with the British Standards Institution code for vacuum sewerage systems BS EN 1091 : 1997.

With its reputation for designing, installing and commissioning its vacuum systems as well as manufacturing products with proven reliability, Iseki RediVac is a world leader in the field of vacuum sewage collection systems.

SECTION 2

THE HISTORY OF VACUUM TECHNOLOGY

The principle of using vacuum pressure to collect waste water and other liquids has been used since the 1860's and many pioneers were involved in the development of the technology, the most successful of which was Mr. Charles T. Liernur.

As can be seen from Figure 1 on the following page, Mr. Liernur's system was used to collect sewage from domestic houses and consisted of an underground storage tank into which the effluent arrived via iron pipes under gravity flow.

The pipes themselves were connected to special toilets within each property and each night a vacuum pressure was applied to the underground tank causing sewage to be removed from the toilets and collected in the tank.

A mobile tanker was then used to remove the sewage from the storage tank by use of vacuum pressure and the sewage was then put into barrels to be later sold to local farmers as fertiliser.

The next developments in vacuum technology were made in the 1920's by Mr. Henri Gandillon from France.

Both sewage and surface water collected from up to 4 houses flowed by gravity into a chamber located within the road. An outlet pipe within this chamber was connected to a main sewer pipe which in turn was connected to a vacuum station.

As sewage entered the chamber, a ball sealing the outlet pipe would float and expose the open end of the pipe. A vacuum pressure was then applied to this pipe by manually opening an isolation valve within the main sewer pipe, thereby causing the sewage to be sucked from the chamber.

There are no records of further developments in vacuum technology until the 1950's when Mr. Joel Liljendhal of Sweden perfected the vacuum toilet first developed by Mr. Liernur.

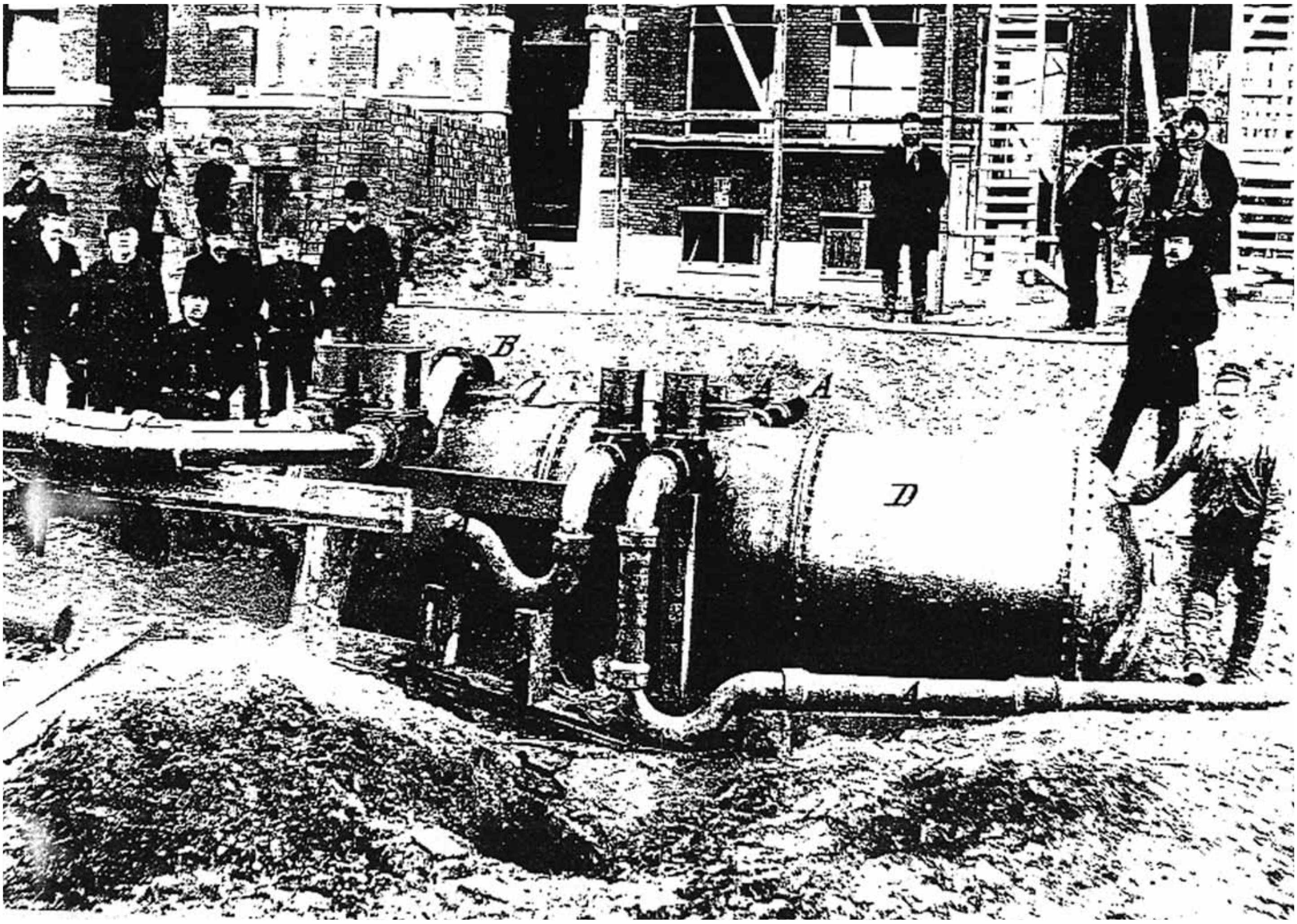


Figure 1 Early Vacuum Sewage Collection Systems

SECTION 3

OPERATION OF A VACUUM SEWERAGE SYSTEM

Vacuum systems can be used to collect a variety of fluids, however they are most commonly used to collect sewage from within domestic housing developments.

Figure 2 below indicates the typical layout of such a system, the three main components of which are as follows :-

Valve Chambers / Sumps
These chambers serve two purposes:

1. To collect the effluent discharged from the connecting properties.
2. To allow the collected sewage to enter the sewer network via the Iseki RediVac interface valve.

The Vacuum Sewers
These form the pipe network through which vacuum pressure is transferred to the Iseki RediVac interface valves within the collection chambers and along which the effluent is transported to the vacuum station.

The Collection / Vacuum Station
This is the heart of the system and is where the vacuum pressure is generated for the whole sewerage network which allows the effluent to be collected and forwarded to the sewage treatment plant.

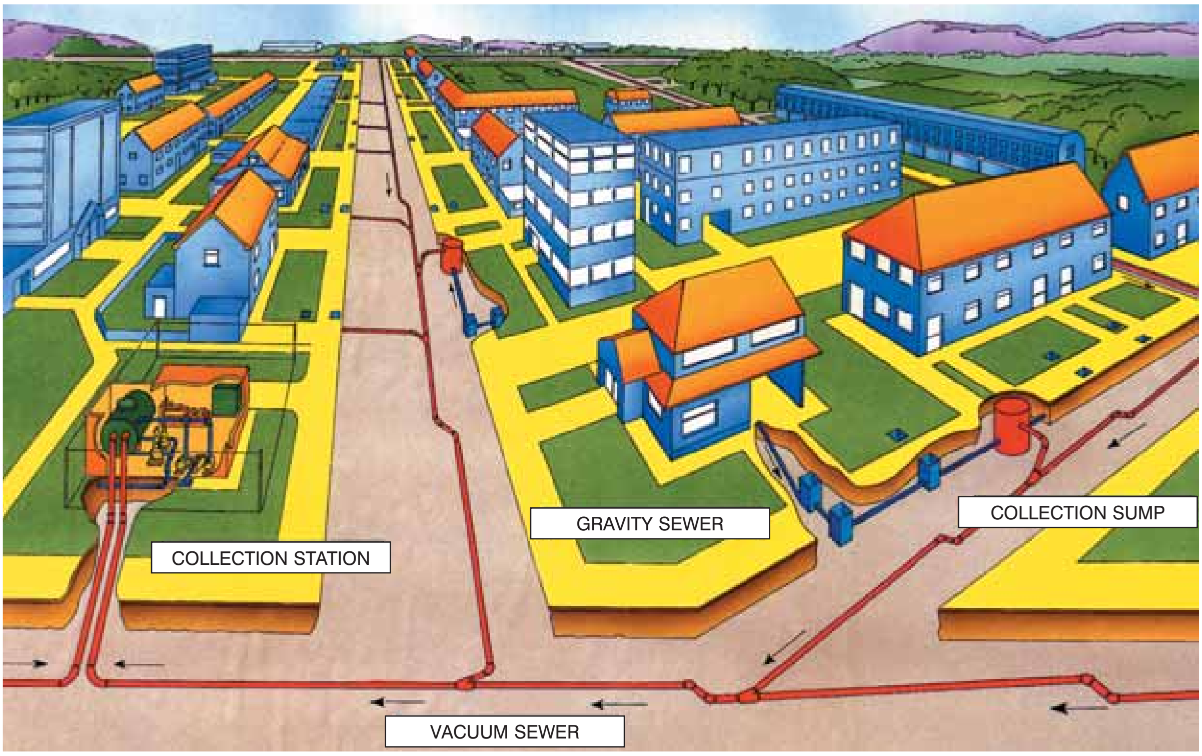


Figure 2 Typical Vacuum Sewerage System Layout

Taking these elements in turn, we begin with the valve chambers and the vacuum interface valves installed therein.

1. Valve Chambers / Sumps

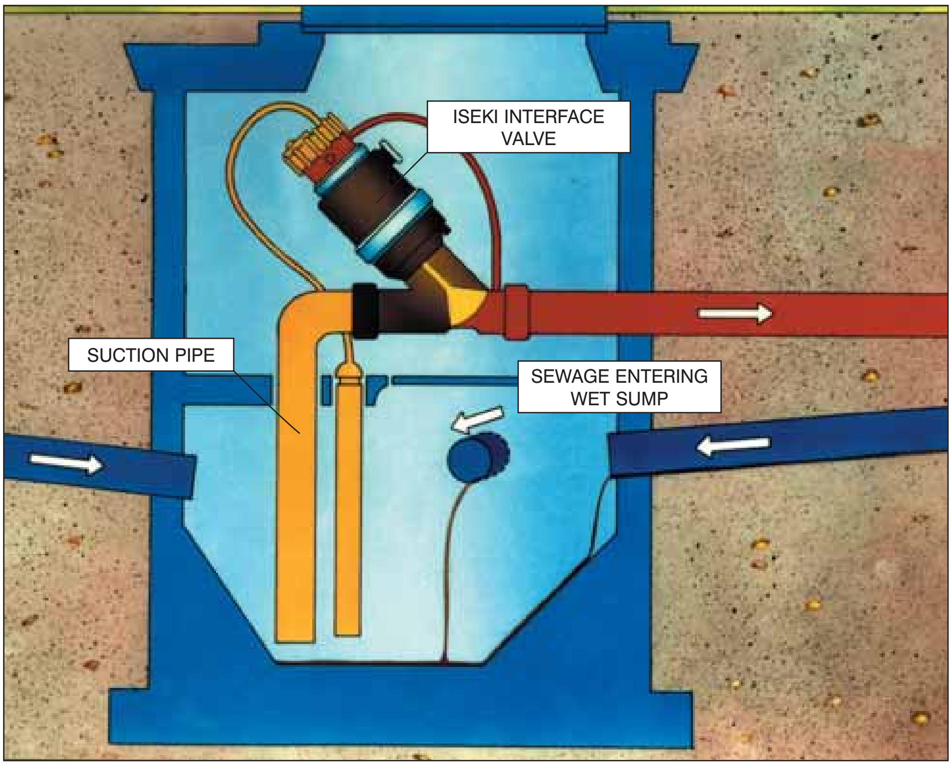


Figure 3.1

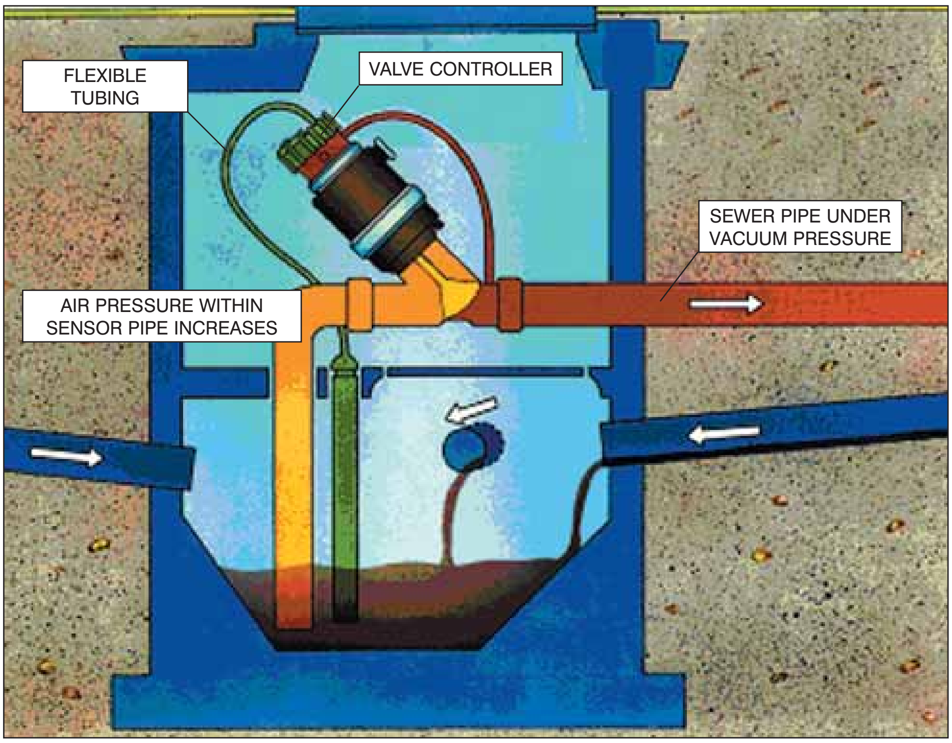


Figure 3.2

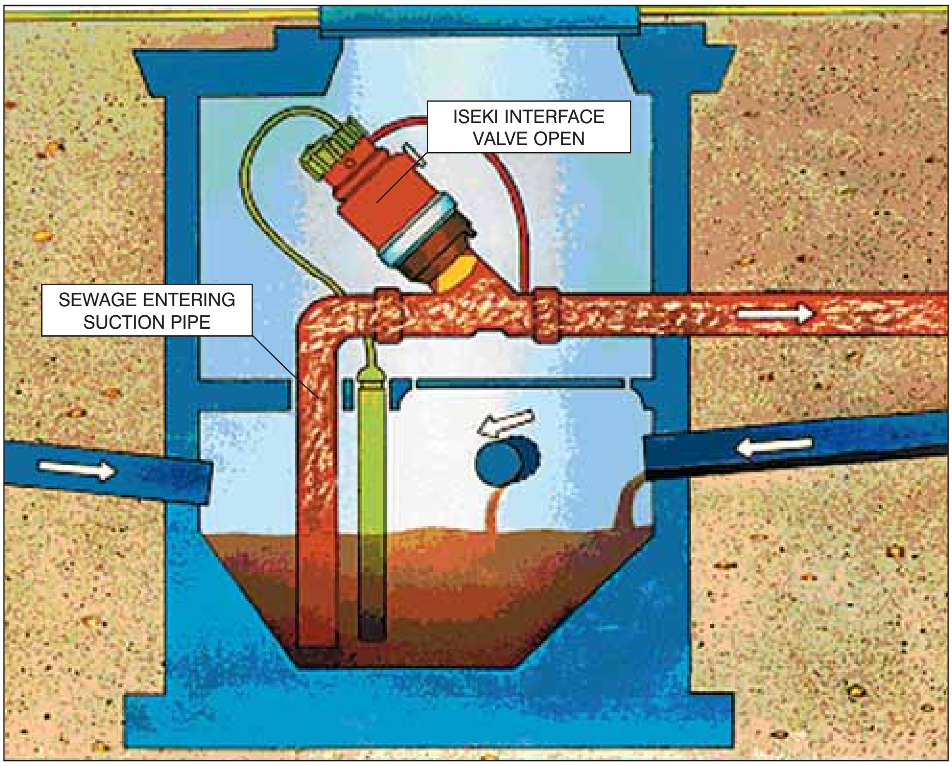


Figure 3.3

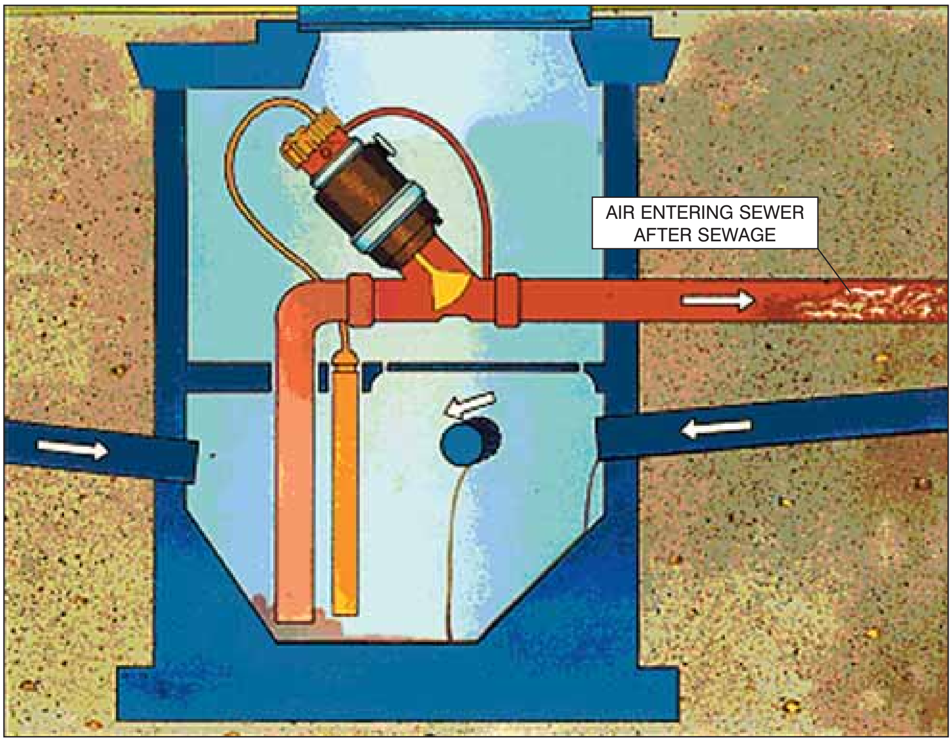


Figure 3.4

Sewage arrives via normal gravity pipes at the lower section, or wet sump, of the collection chamber just like a manhole in a conventional gravity system (see Figure 3.1).

As the level of the effluent within the wet sump rises, air is trapped in a pipe called a 'sensor pipe', the pressure of which increases as the effluent level continues to rise (see Figure 3.2).

This increase in air pressure is subsequently transferred via flexible tubing to the top section of the interface valve which is known as the 'controller'.

Eventually this pressure becomes great enough to operate a switch within the controller which then allows vacuum pressure to be transferred to the main body of the valve and cause it to open.

With the valve in the open position, air at atmospheric pressure acting on the surface of the liquid within the wet sump then forces the sewage into the 'suction pipe', past the interface valve and onward into the sewer pipe network (see Figure 3.3).

Once all of the sewage has been removed from the wet sump, the valve remains open for a short period of time to allow air at atmospheric pressure to enter the sewer pipe network (see Figure 3.4).

The valve then closes under the action of a spring to complete one cycle.

2. The Vacuum Sewers

The sewage is now within the second element of the system, namely the vacuum sewers and typical profiles of these sewers can be seen in Figure 8 in the appendix.

The diameter of the pipes is between 90mm to 250mm and they are normally constructed from High Density Polyethylene (HDPE) jointed using electro-fusion welding collars.

It is the air admitted through the interface valve that is the means by which the sewage travels along these sewer pipes.

Initially the sewage travels at velocities of up to 6m/s as a foaming mixture of liquid and air. The velocity gradually reduces as the mixture moves along the sewer and the air eventually overtakes the liquid and continues onward towards the vacuum station.

At this point the vacuum sewers act exactly like conventional gravity pipes and the sewage travels within them by normal gravity flow.

Eventually the sewage comes to rest at low points within the sewers called 'invert lifts' and remains stationary. The next time an interface valve opens and allows air to enter the sewer network, this sewage is lifted from the low point and transported onward towards the vacuum station (see Figures 3.5 to 3.7).

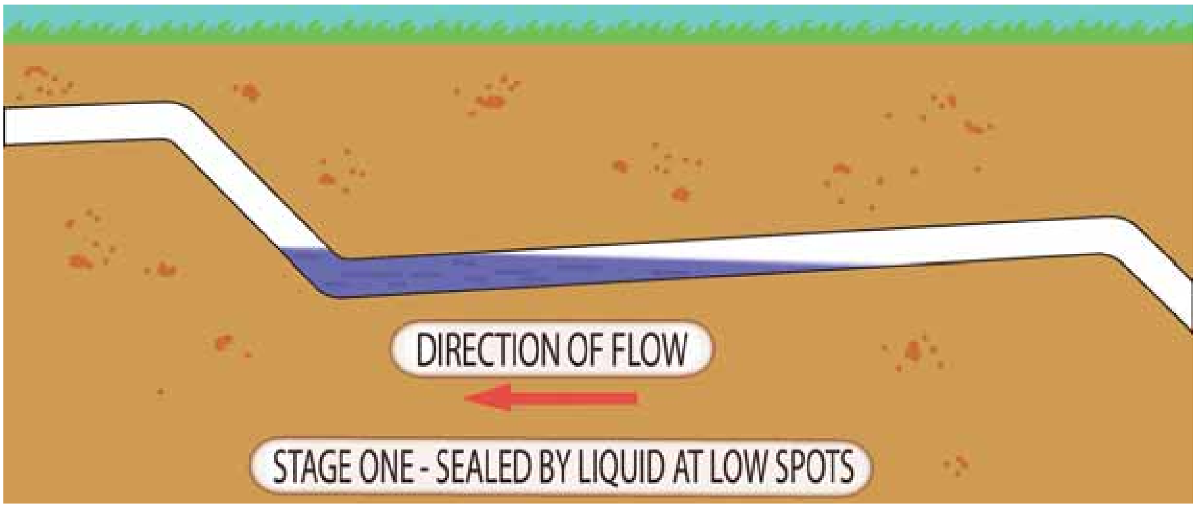


Figure 3.5

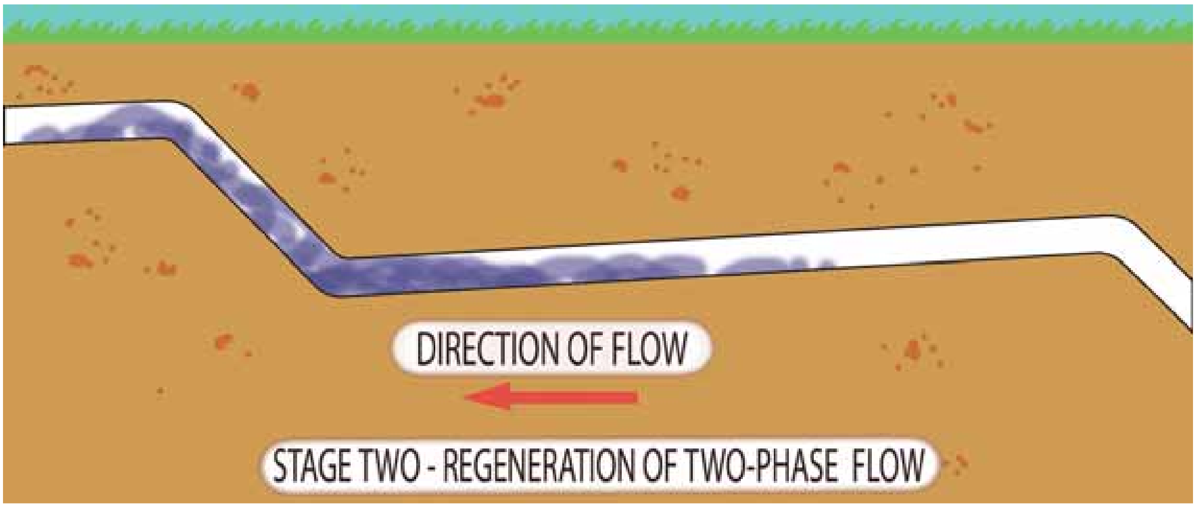


Figure 3.6

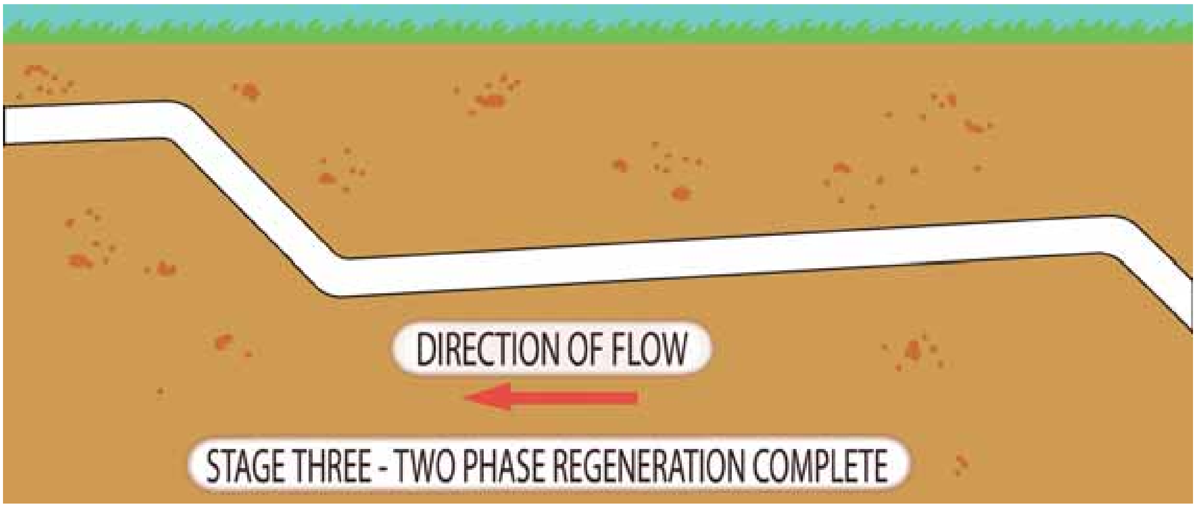


Figure 3.7

3. The Collection / Vacuum Station

Finally, the sewage reaches the vacuum station, which is the third element of the system.

The main items of equipment within the vacuum station are vacuum pumps, a collection vessel, sewage discharge pumps and an electrical control panel (refer to Figure 4).

The vacuum pumps are connected to the collection vessel via pipework and they create the vacuum pressure within both the vessel and the connecting vacuum sewers.

The arriving sewage is initially stored in the collection vessel which acts as the wet sump normally found within a conventional gravity pumping station.

Rising sewage levels within this collection vessel are detected by level probes which initiate the operation of sewage discharge pumps connected via pipework to the vessel.

These pumps remove the collected sewage from within the vessel and forward it to the local sewage treatment plant or nearby main sewer.

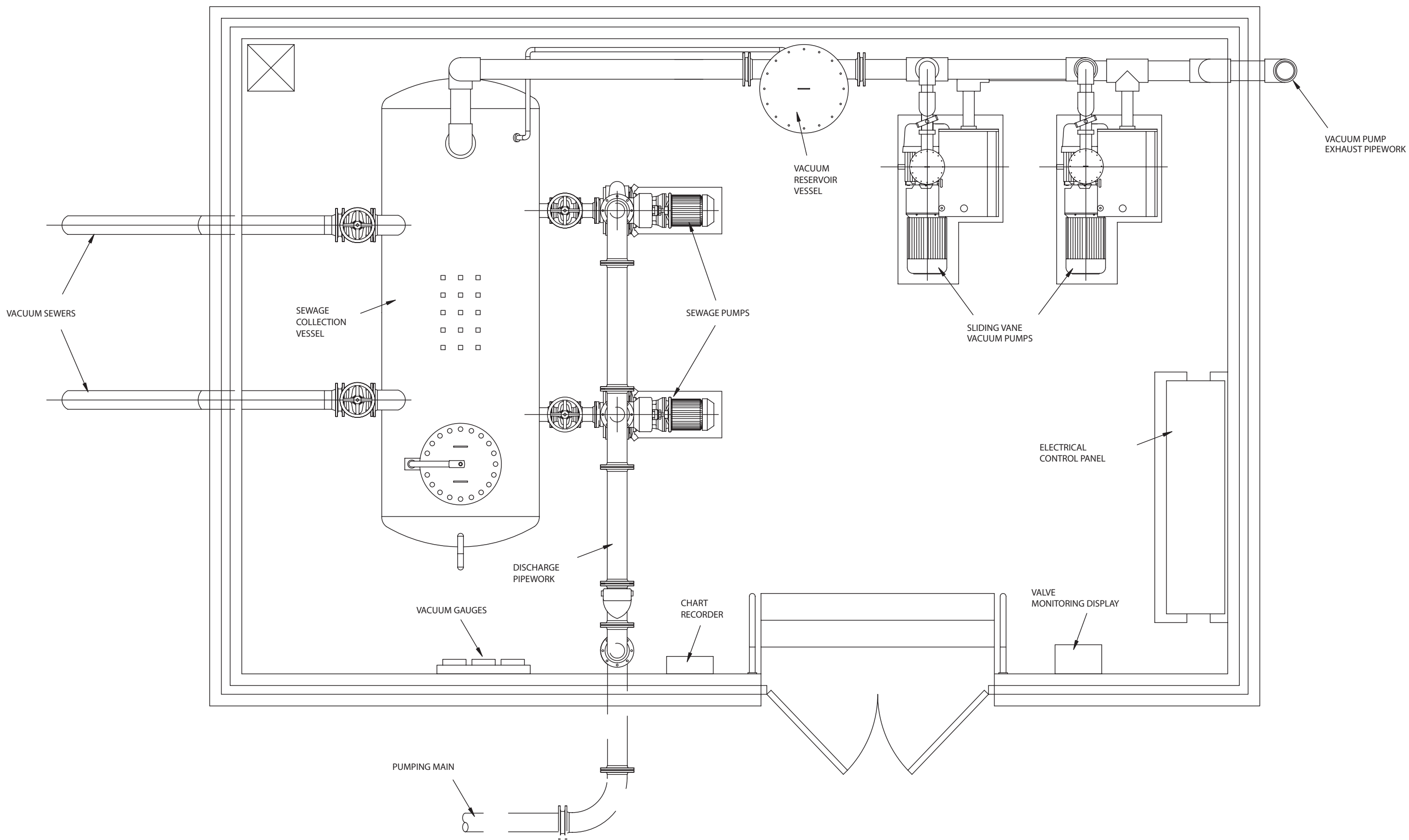


Figure 4 Typical Vacuum Station

SECTION 4

ADVANTAGES OF VACUUM SEWERAGE SYSTEMS

The decision to use a vacuum sewage collection system instead of a conventional gravity system offers three main benefits :

1. **Design flexibility**
2. **Capital cost savings**
3. **Operational cost savings**

1. Design Flexibility

The inherent versatility of vacuum systems gives clients flexibility in their approach to solving their fluid collection problems.

Below are just a few of the benefits which can be gained through the flexibility available when designing vacuum fluid collection systems:

1. Without restrictions on the line or level of vacuum sewers, the pipes can be installed as required to suit the site conditions.

2. Lightweight small diameter sewer pipes allow ease of installation where access is restricted.

3. The self-cleansing nature of vacuum sewers removes the requirement for rodding eyes and washout chambers.

4. With effluent being conveyed by vacuum pressure rather than gravity flow, sewage can be transported uphill.

5. Due to 4. above, the vacuum stations need not be located at the low lying areas within a development. This flexibility of station location can provide significant benefits if land availability is restricted or environmental constraints are imposed within the development.

6. Obstacles can be easily negotiated by re-routing the vacuum sewers over, under or around obstructions.

2. Capital Cost Savings

Capital cost savings in excess of 40% are possible through the construction of vacuum sewage collection systems due to the following:

1. Trench excavations required for constructing the sewer pipe network are narrow and shallow (maximum sewer depths are 1.5 metres).
2. The speed of construction is greatly increased due to (1) above.
3. High water tables can be avoided due to shallow sewer pipes.
4. No requirement for piled sewer foundations through the use of the lightweight polyethylene pipework from which the sewers are constructed.
5. No requirement for manholes at sewer direction changes therefore manhole numbers are reduced.
6. Vacuum collection chambers are installed at a maximum depth of 2 metres throughout the sewer network.
7. Reduced depth of vacuum station foundations (typical depth 1 metre).
8. Only one vacuum station is required for a single development whereas conventional gravity systems usually require several pumping stations.
9. Additional land available within development due to (8) above.

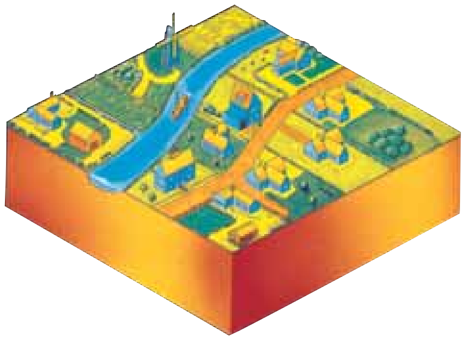
3. Operational Cost Savings

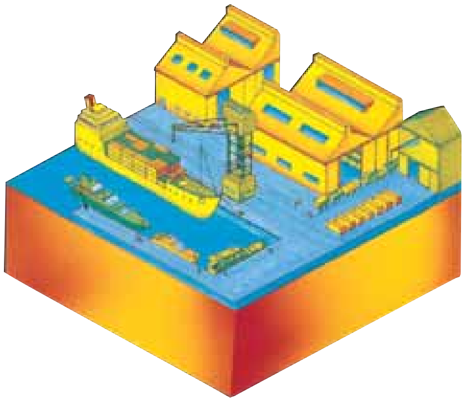
Operational cost savings can be reduced by up to 30% due to the following:

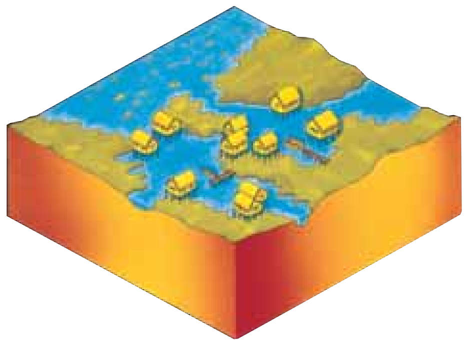
1. Vacuum sewers are self-cleansing therefore there is no requirement to clean or remove sediments from within the vacuum sewers.
2. There is no requirement for screens at the vacuum station and therefore weekly visits to the station are not needed.
3. Only one vacuum station is needed to be maintained whereas a gravity system will have several pumping stations requiring regular attendance.
4. There is no infiltration of ground water into the vacuum sewers and therefore pump sizes and subsequently electrical power consumption are significantly reduced.
5. The cost of treatment is greatly reduced due to 4. above.
6. The integrity of the vacuum sewers is maintained throughout the lifetime of the system due to the robust material from which the sewers are constructed (polyethylene).
7. No need for repairs arising from settlement of pipework due to 6. above.

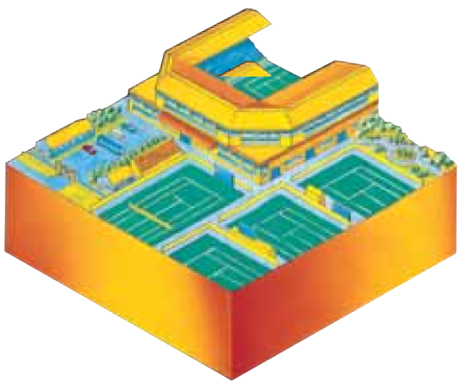
SECTION 5

APPLICATIONS OF VACUUM TECHNOLOGY









Vacuum fluid collection systems can be employed in a wide range of situations and typical applications of this versatile and environmentally friendly technology are indicated below:

- Rural community main sewerage
- Roof drainage
- Camp and caravan sites
- New housing developments
- Old towns with narrow streets
- Hospital effluent collection
- Shopping centres with difficult or confined areas
- Replacement of conventional gravity systems
- Petro-chemical industry
- Factory sewerage
- Arctic communities
- Leachate from landfills
- Spillage around industrial storage tanks
- River, lakeside and coastal communities
- Quayside re-developments
- Ship to shore sewage collection

For examples of the above applications please contact Iseki RediVac or their local representative.

SECTION 6 A SELECTION OF ISEKI

Client	Location	Country	Year
Anglian Water	Walpole St. Peter Extension	UK	2004
Southern Water	Bromley Green Upgrade	UK	2004
Southern Water	Yalding Upgrade	UK	2004
Tisice Village	Czech	Czech Republic	2004
Philcor Pty	Sanctuary Lakes Extension 2	Australia	2004
ISA Polska Zoo	Rajeckie Pieńki	Poland	2004
ISA Polska Zoo	Czermin	Poland	2004
ISA Polska Zoo	Cerekiew	Poland	2004
ISA Polska Zoo	Lęcana Phase 2	Poland	2004
ISA Polska Zoo	Ceglów	Poland	2004
ISA Polska Zoo	Michów phase 2	Poland	2004
Rapidan Service Authority	Lake of the Woods Extensions	USA	2004
Inárcs Operating Co	Inárcs Phase 2	Hungary	2004
Hidepito	Röszke Phase 2	Hungary	2004
VITEP	Szigetujfalu	Hungary	2004
Envitech	Bandar Botanic Parcel 2	Malaysia	2004
Hidepito	Domaszek Phase 2	Hungary	2003
U.V.I.E.P KFT	Korostarcsa Phase 2	Hungary	2003
Philcor Pty	Sanctuary Lakes Extension 1	Australia	2003
ISA Polska Zoo	Lęcana	Poland	2003
ISA Polska Zoo	Wiazownica	Poland	2003
ISA Polska Zoo	Michów	Poland	2003
ISA Polska Zoo	Nadarzyn Phase 2	Poland	2003
ISA Polska Zoo	Wacyn, Briel	Poland	2003
ISA Polska Zoo	Abramàw	Poland	2003
Develop Whitwell	Whitwell	UK	2003
Vegyesipari Szolgaltato	Pilis Phase 2	Hungary	2003
Deacon Caravan Park	Benone Phase 2	Northern Ireland	2003
Yorkshire Water	Rosedale Abbey Refurbishment	UK	2003
Anglian Water	New Bollingbrook Upgrade	UK	2003
Sharjah University	American University Phase 6	UAE	2003
Anglian Water	West Dale Refurbishment	UK	2003
Sharjah University	Etilsalat College	UAE	2003
Centroprojekt	CSN Steel Works	Brazil	2003
Severn Trent	Arlingham	UK	2003
Envitech	Botanical Gardens Phase 2	Malaysia	2003
Binder	Holton Hall	UK	2002
Severn Trent	Four Crosses Service	UK	2002
Anglian Water	Gorefield	UK	2002
Envitech	Bandar Botanic Parcel 1	Malaysia	2002
Anglian Water	Maltby-le-Marsh Upgrade	UK	2002
Anglian Water	Holton & Raydon Upgrade	UK	2002
Infrastart Kft	Monori Erd.	Hungary	2002
Anglian Water	Holton Hall Business Park	UK	2002

REDIVAC WORLD-WIDE PROJECTS

Client	Location	Country	Year
Hidepito	Abony	Hungary	2002
Vakond	Toszeg	Hungary	2002
ISA Polska	Nadrzyn	Poland	2002
Anglian Water	Tydd St Giles	UK	2002
ISA Polska	Zakrzew	Poland	2002
Innoterv Rt	Szigetbecse	Hungary	2001
Infrastart Kft	Monor	Hungary	2001
Anglian Water	Orby refurb	U.K.	2001
infrastartKft	Gomba	Hungary	2001
Innoterv Rt	Dömsöd	Hungary	2001
Severn Trent	Four Crosses - Station Upgrade	U.K.	2001
Infrastart Kft	Csévharaszt	Hungary	2001-02
Innoterv Rt	Makád	Hungary	2001
Innoterv Rt	Ráckeve	Hungary	2001
NOOSA	Queensland	Australia	2001
Envitech	Pulau Indah Section 10	Malaysia	2001
Vakond Kft	Tiszavárkony	Hungary	2001
Vakond Kft	Tiszajen	Hungary	2001
Vakond Kft	Tószeg	Hungary	2001
Infrastart Kft	Vasad	Hungary	2001-02
Vakond Kft	Vezseny	Hungary	2001
ISA Polska	Lubwin	Poland	2001
Thargomindah Village	New South Wales	Australia	2001
Innoterv Rt	Orgovány	Hungary	2000
Sharjah University	Phase 4	UAE	2000
Innoterv Rt	Izsák	Hungary	2000
Coomera Marine Precinct	Brisbane	Australia	2000
Toowoombah	Brisbane	Australia	2000
Philcor Pty	Minamurra, New South Wales	Australia	2000
Plantation	Florida	USA	2000
Philcor Pty	Sanctuary Lakes 7&8 Melbourne	Australia	2000
North Slope Borough, Alaska	Nuitsut village, Package Vacuum Stn	USA	2000
Philcor Pty	Falcon, Perth	Australia	2000
Philcor Pty	Sydney Harbour	Australia	1999
Hepburn & Thorpe	Coomera Village	Australia	1999
Innoterv Kft	Ágasegyháza	Hungary	1999-00
Dept of Environment	Benone Extension	Ireland	1999
Philcor Pty	Water Fall Gully	Australia	1999
Sharjah Municipality	Police Academy - Sharjah University	UAE	1999
North Slope Borough, Alaska	Aqusik Village, Package Vacuum Stn	USA	1999
Thames Water Services	Wraysbury Village - Windsor	UK	1999
City of Virginia Beach	Salem Road	USA	1999
City of Virginia Beach	Alanton Road Phase 2	USA	1999
Thames Water Services	Hamm Court - refurbishment London	UK	1999

SECTION 7

ISEKI REDIVAC MATERIALS AND EQUIPMENT

THE INTERFACE VALVE TEST

In order to satisfy the requirements set out in the British Standard document BS EN 1091:1997 entitled 'Vacuum Sewerage Systems Outside Buildings', Iseki RediVac tested their interface valve as described in Section 7, paragraph 7.1.2 and Annex A paragraphs A.2, A.3 and A.4 of the document which reads as follows:

A.2 The interface unit shall have a proven ability to undertake a specified number of cycles without attention other than the manufacturer's recommended maintenance and still function effectively. The specified number of cycles shall be the greater of

a) The number of cycles needed to evacuate 3,000m^3; or
b) 250,000 cycles.

Iseki RediVac carried out the test based on part (b) of the above section.

A.3 The test requires selected foreign matter to be cycled through the interface valve. Corks, plastic bags, sanitary towels and disposable nappies and other foreign matter are water logged and feed into the collection chamber piece by piece over ten cycles in random order. All foreign matter is to be sucked through the test rig without any blockages.

A.4 The vacuum shall be released and the collection chamber sump shall be filled with water sufficient to cover the top of the interface valve body by 300mm. The breather tube shall not be submerged. After remaining submerged for 24 hours the vacuum shall be restored and the interface valve mechanism cycled 20 times. The test shall be undertaken 3 times.

A registered quality lead assessor named John Edward & Associates witnessed the testing of Iseki RediVac's interface valve and upon completing the tests as specified above, the valve was certified as shown on page 24.

Tested to BS EN 1091:1977

Interface valve performed more than 250,000 cycles

JOHN EDWARDS & ASSOCIATES
ENGINEERING CONSULTANTS
19 ASHLEIGH ROAD, SOLIHULL, WEST MIDLANDS B91 1AE.
TELEPHONE: +44(0)121 705 1228 FAX: +44(0)121 705 4890
E-mail: emas.john@dial.pipex.com

15th March 1999

Testing of Iseki 90mm Vacuum Interface Valves
to BS EN 1091 : 1977

This is to confirm that I have witnessed the testing of a 90mm Iseki Vacuum Interface valve under simulated working conditions to the requirements of BS EN 1091 : 1997, in particular the requirements of para 7.1.2. The valve completed 250,000 cycles without maintenance and was still working completely satisfactorily when the test was terminated. Subsequent strip down of the valve revealed negligible wear in all the moving parts.

John Edwards

John Edwards
Chartered Engineer
Registered Quality Lead Assessor

PRINCIPAL J. H. EDWARDS M.B.E., B.A., C.ENG., F.I.MECH.E., M.I.MGT., M.I.Q.A.

JOHN EDWARDS & ASSOCIATES

ENGINEERING CONSULTANTS

19 ASHLEIGH ROAD, SOLIHULL, WEST MIDLANDS B91 1AE.
TELEPHONE: +44(0)121 705 1228 FAX: +44(0)121 705 4890
E-mail: emas.john@dial.pipex.com

THIS IS TO CERTIFY THAT
ISEKI 90MM VACUUM INTERFACE VALVES
FULLY SATISFY
THE TESTING AND VERIFICATION CONDITIONS
AS LAID DOWN IN PARA.7.1.2 AND ANNEX A
(NORMATIVE) PARAS A.2, A.3 AND A.4
OF BS EN 1091:1997

PRINCIPAL J. H. EDWARDS M.B.E., B.A., C.ENG., F.I.MECH.E., M.I.MGT., M.I.Q.A.

ISEKI REDIVAC INTERFACE VALVE MONITORING SYSTEM

The Iseki RediVac Interface Valve Monitoring System detects the status of each interface valve on a vacuum system and indicates whether the valve is open or closed on a display panel located within the vacuum station.

This is an essential operational tool as it pinpoints valves which have failed to close properly and are therefore causing a loss of pressure within the vacuum system. A loss of pressure is generally caused by a foreign object preventing the plunger inside an interface valve from properly sealing the sewer pipe and it is at this stage that the monitoring system becomes invaluable in locating the troublesome valve.

The method of operation is simple. A switch attached to the body of each interface valve detects whether the valve is open or closed and relays this information to the vacuum station via a signal cable installed alongside the vacuum sewer pipes.

Within the vacuum station a Light Emitting Diode (LED) display then indicates the open and closed status of each valve, with an LED being illuminated when a valve is open.

Examination of the display panel will indicate which interface valve has failed to close as each valve has a unique identity code. A visit to the valve chamber housing the valve will then allow the problem to be rectified.

When pressure losses are occurring on the vacuum system, the speed at which problem valves can be identified is greatly increased using this system. This in turn significantly reduces the time required on site by maintenance crews and allows the vacuum system to be quickly returned to normal operation.

Connection of collection chambers to valve monitoring system

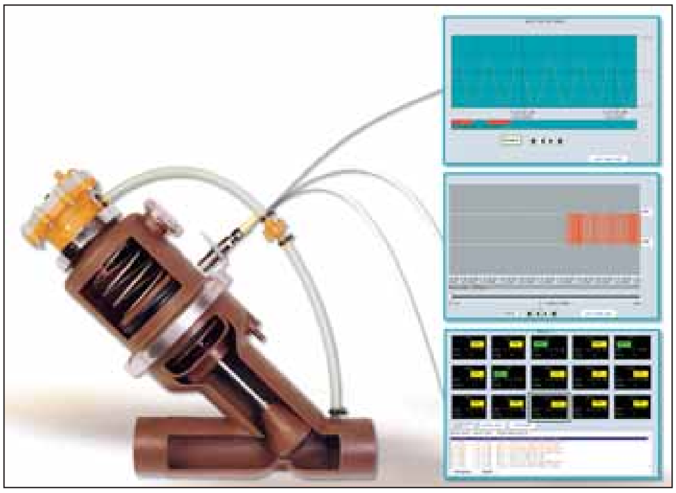
Laying of valve monitoring cable within sewer trench

‘INTELLIGENT’ MONITORING SYSTEM

Fundamental to the system is a sensor on each Iseki Redivac interface valve which relays a signal to a central monitoring computer whenever a valve operates. The monitoring computer will constantly display the current situation within the collection system indicating which valves are in operation at any one time. This replaces the wall mounted display panel with LEDs showing the open or closed status of each valve.

The benefits of the new system are many. All information is stored for a minimum of 28 days allowing the operator to evaluate the efficiency of all the interface valves. This enables the operator to quickly identify the valve’s frequency of operation and identify any unusual patterns. Any failure in the system itself or unusually heavy flow rates are easily identified allowing the operators to resolve the situation quickly and efficiently.

Iseki RediVac’s new management information system will bring considerable cost efficiencies in operation as well as identifying maintenance scheduling for each interface valve. This exciting development will allow accurate targeting of maintenance and enhance the overall performance by providing an instant wide-angled view of the entire installation.



‘Intelligent’ Monitoring System

SEWAGE HIGH LEVEL ALARM SYSTEM

Iseki RediVac have devised and implemented a system for monitoring the level of sewage in the collection pits around the sewer network. An alarm is raised to alert the operations staff of an overflow in a particular vacuum chamber identified by the LED display panel within the vacuum station. Furthermore ‘real time data’ can be collated and stored to provide benefits, for example; trending on location, frequency of occurrence, response of maintenance crews and their efficiency in dealing with the problem.

System Components

- An armoured twin pair electrical cable is provided and laid within the vacuum sewer pipe trench. This has the ability to link all the vacuum chambers, via the cable, with equipment located within the vacuum station.
- A high level float switch is placed within the sump and calibrated to activate a switch at a predetermined level before the sump reaches flood level.
- Within the vacuum station is an LED display panel with one LED for each vacuum chamber. In the event of flood conditions being detected the corresponding LED within the panel will illuminate.

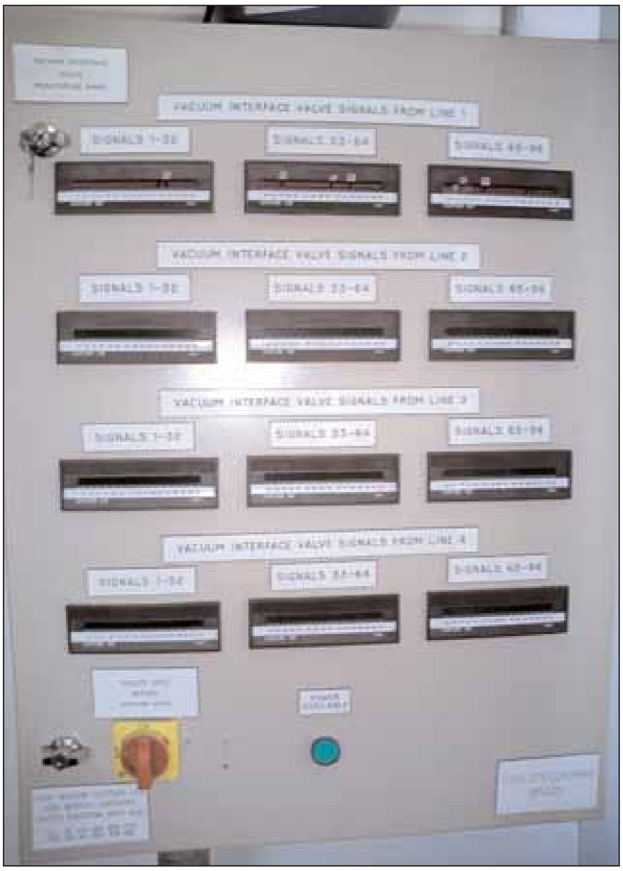
Valve chamber fitted with high level warning equipment.

VALVE MONITORING PRINCIPLES

Data Processing and Benefits

- As all sumps are linked together in a loop back to the station and as each sump has a dedicated signal the receiver is able to monitor if any particular switch has been activated by the high level switch.
- Data can then be processed and forwarded in the form of an alarm to a central control room where it can be specifically identified by the operations personnel.
- Appropriate actions can then be taken, such as calling out the maintenance crew, or putting the alarm on standby to allow a recovery period to bring the sewage level down to an acceptable level.

Valve monitoring transmitter installed on Iseki RediVac Interface Valve



Valve monitoring display panel housed within vacuum station

- By installing further software, all such incidents for each sump can be stored for extended periods and data provided for historic analysis.
- The actions of maintenance crews to such a call out can be recorded, such as their efficiency and attendance on site.
- Software programmes can be installed to provide various levels of information and statistics to suit the individual client's requirements.
- All results can be presented in data or graphic format and easily stored for historic purposes.
- The technology usually operates in parallel with the ISEKI REDIVAC VALVE MONITORING SYSTEM.
- The system is installed during the main construction period which has the advantage of minimising installation costs.
- By incorporating this equipment in a vacuum sewerage system the frequency of routine site attendances can be greatly reduced.

TYPICAL VACUUM STATION EQUIPMENT

Rotary vane, single stage oil-sealed vacuum pumps

Dry well, centrifugal screw sewage discharge pumps

Motor Control Centre complete with integral PLC and valve monitoring console

Steel sewage collection vessel

Sensor probes and switches

Biological Filtration Unit

SECTION 8

ISEKI REDIVAC'S SCOPE OF SERVICES

Below are details of the services which Iseki RediVac are able to offer to clients considering using vacuum sewerage technology.

1. Vacuum System Cost Estimates

Initially clients generally wish to compare the capital cost of installing a vacuum system against that of using a more conventional sewage collection system.

To assist with this, Iseki RediVac will examine layout plans of the proposed development and produce a conceptual design of a vacuum sewerage system.

From this, specific information such as the number of collection chambers, sewer pipe sizes and vacuum station dimensions can be established and a budget cost estimate produced for the client to examine.

2. Detailed Engineering Design and Construction

If the client decides to proceed with the vacuum option, Iseki RediVac can produce detailed designs of their vacuum systems including engineering drawings and specifications which can then be offered to civil engineering contractors for pricing.

Alternatively, Iseki RediVac is able to offer TURNKEY or even BOOT packages to clients for the design and construction of their vacuum systems.

3. System Commissioning and Training

Upon completion of the vacuum system, Iseki RediVac's engineers will perform a full commissioning of the system in readiness for on-line operation.

As part of this service, Iseki RediVac will also introduce the client's maintenance staff to vacuum technology and carry out training in the day to day operation and maintenance of the system.

4. Servicing of Existing Vacuum Systems

Iseki RediVac can offer maintenance and service packages ranging from simple appraisals through to full refurbishment of clients' vacuum systems.

With a number of diagnostic tools available to Iseki RediVac's engineers, a survey of an existing vacuum system can establish information such as real time vacuum pressure levels, pump operations, actual sewage flows and interface valve activity.

With this information to hand, Iseki RediVac's engineers can advise operating staff on the performance levels of their vacuum systems and offer solutions to help maximise operational efficiencies.

SECTION 9

FREQUENTLY ASKED QUESTIONS

This section raises some of the most frequently asked questions that are asked of Iseki RediVac's engineers. They have been divided into broad categories to assist the reader in identifying questions of a particular nature.

One such question is 'In what situations may a vacuum system be used?'

Vacuum systems have been used in a great variety of locations and operational requirements. In the UK many systems are used to provide first time sewerage schemes for communities that, due perhaps to poor ground conditions or difficult topography, are uneconomical to sewer by conventional means.

Additionally, the flexibility of the system has led to its use in many different applications such as Wimbledon Tennis Club, to drain water from the roofs at Centre Court and No. 1 Court, and in Malaysia to sewer communities of 20,000 inhabitants.

Attached is a list of vacuum systems installed over the last fifteen years or so, which will give an indication of the number and variety of applications.

It is worth noting that internationally recognised consultants such as Halcrow, Parsons, Watsons, Acers, Dames and Moore, Babtie, WSAtkins, Khatib & Alami, Haswell and many others have worked with the Iseki RediVac vacuum technology and are actively studying further applications.

Construction

1. What size of trench is required for a vacuum sewer?

In general, the width of the trench will be dictated by the construction method employed. For example, if a trenching machine is available and the ground conditions allow, the trench may be only 100mm wider than the pipe diameter. Back hole excavated trenches are typically 450mm in width.

It would, of course, be necessary to increase the width when using a trenching machine where man entry is required to make joints.

2. What depth of trench is needed?

Usual practice demands the pipe cover to be approximately 900mm under normal traffic load conditions (to withstand wheel loadings), and about 500mm to 700mm under walkways etc.

3. What bed and surround material is used?

This will be dependent upon the local codes for the pipe material used. Typically in the UK, for example, a bed of 100mm of granular fill with a cover to the crown of the pipe of a further 150mm of granular material. However, the vacuum main does not require any different bedding to be used than for a water main in a similar pipe material.

4. Is the use of marker/tracer tapes recommended with vacuum sewers?

Yes, this is good practice.

Interface Valve

1. What is the life of a vacuum interface valve?

The Iseki RediVac interface valve can be expected to last in excess of 25 years. Approximately every seven years we recommend that bearings and rubber diaphragms are replaced.

2. Of what material is the interface valve made, where is it manufactured and are spare parts readily available?

The valve is made of glass filled polypropylene with all metal components being of 316(A4) stainless steel. The Iseki RediVac interface valve is manufactured by Iseki Vacuum Systems at their Daventry factory in the UK. Spare parts are also available at Daventry or from one of Iseki RediVac's many official distributors or service centres situated throughout the world. All spare parts are ex-stock.

3. Are any specials tools required to service the valve?

No, a standard tool kit used by a maintenance fitter will contain all that is necessary to carry out a service of the Iseki RediVac interface valve.

4. How many properties may be connected to a single interface valve?

This is not a question that can be answered with a single definitive figure. At the design stage many factors are taken into consideration such as the size of the main onto which the valve is connected, the position of the valve within the overall network and the number and configuration of adjacent valves.

In general, it is advantageous to keep the number of properties per valve higher rather than lower, as the more frequent firing of the valve will optimise the transportation of the sewage in the mains. The less sewage that remains in the sump, the less likelihood of septicity setting in before sewage reaches the treatment plant. The Iseki RediVac valve offers considerable advantages as it has a variable timer on the air cycle of the valve opening, which offers more design and operational flexibility.

Iseki RediVac designs to optimise efficiency in every case, which is based upon flow and storage requirements. In this way Iseki RediVac is able to offer the optimum technical solution with the most competitive price.

5. How many interface valves may be connected to a single vacuum sewer main?

Again this is not a question that can be answered with a single definitive figure. The factors affecting this will be the number of properties connected to each of the sumps, the size of the vacuum main (which is usually but not always the deciding factor), the length of the main, the longitudinal profile of the main and the distances from the collection station of the greatest density of properties on the main.

All of these factors are taken into account by Iseki RediVac when designing a vacuum sewerage system.

The variable valve air cycle timer described in 4 also has the benefit of enabling the design of the vacuum sewers themselves to be tailored to suit local requirements.

6. Is the sensor pipe prone to blockage or damage, and if so what are the consequences?

In an Iseki RediVac system the relative positions of the suction pipe and the sensor pipe are carefully designed so that each firing of the valve causes turbulent suction, cleansing the sensor pipe, because of its proximity to the suction pipe.

However, should the pipe become blocked, the only part of the system affected would be the valve in that particular chamber, not the whole system. The problem can be remedied easily without special tools and without the need to shut down any part of the sewerage system. Where any cleaning may be necessary it can easily be carried out during the execution of your scheduled maintenance programme.

7. Is the breather pipe prone to blockage or damage, and if so what are the consequences?

The breather pipe from the controller on the valve to atmosphere is an important component of the system. It is therefore necessary to protect it from damage and there are two distinct ways in which this can be achieved. Firstly, the upstand section of the breather pipe, i.e. that part above ground, can be positioned adjacent to a building or fence that will offer it protection from accidental damage. Secondly, it can be installed into a strong galvanised or stainless steel protection post. Iseki RediVac will be very pleased to discuss this matter in more detail if you wish.

However, should the breather pipe be damaged, the only part of the system affected would be the valve in that particular chamber, not the whole system. The damaged pipe can be replaced without the need to shut down any part of the system.

8. What is the individual valve monitoring equipment?

It is a system that monitors the opening and closing of valves and is an invaluable trouble-shooting tool. The display identifies exactly which valve may be malfunctioning and without any system shutdown can be checked and if necessary replaced for maintenance. The replacement would take about 15 minutes and causes no disruption to system users.

Valve Chamber

1. Do the valve chambers have to be sealed against rain or surface water?

No, it is not absolutely necessary in all situations. However it is good practice to do so, then only sewage is transported to the treatment works. Transporting and treating rainwater is clearly unnecessary and expensive.

2. Does the collection sump require regular cleaning?

In normal operation the sump is self cleansing, and the only effluent ingress to the chamber in normal operation is via the lateral connections, which limits the size of objects that can enter the chamber. However, manual clearing or jetting is recommended during an annual inspection of the collection chamber and interface valve. This can be simply achieved by entering the chamber via the manhole or use of a water jetter from the road level.

A feature of the Iseki RediVac systems collection chamber is the slab midway in the chamber, called the landing platform. It is positioned between the valve compartment and the wet sump. This acts as a barrier, stopping any objects being introduced through the manhole from falling into the sump itself and the landing platform can also be used by maintenance engineers to stand on when carrying out any scheduled maintenance to the interface valve.

3. If foreign objects do enter the sump (such as plastic sheeting, food packaging etc), what are the consequences?

Please refer to the Iseki RediVac video, ‘Interface Valve Handling Capabilities’ which shows various such materials and objects passing through the Iseki RediVac valve.

Sewers and Equipment

1. What pipe materials and pressure ratings are required for a vacuum main?

The material from which the vacuum mains are constructed may vary depending upon what is most economical in a particular country. In the broadest sense of the question any material that can be jointed in a vacuum-tight way and can withstand wheel loading when buried with an internally applied pressure of up to minus one Bar would be acceptable.

However, in practice the preferred material is undoubtedly high density polyethylene (HDPE) with the jointing method being electro-fusion. The wall thickness specified by Iseki RediVac for HDPE pipe used in the UK would be SDR 17.6. For more details regarding Iseki RediVac's recommendations for pipe thickness and strength in other countries please refer to Iseki RediVac's specification for your area or contact your Iseki RediVac Agent or Distributor.

The pipeline is extremely robust and because the vacuum tests carried out during laying ensure its complete integrity, no ingress of ground water can occur.

2. What is the storage or retention capacity within the system?

This will depend upon the particular project and the projected flow regimes. At the design stage of the project the required storage capacity will be calculated and built into the design.

One way in which the retention time can be extended is by the use of double chambers; i.e. a 'wet' chamber into which the gravity sewers from properties discharge and a 'dry' chamber housing the valve. The 'wet' chamber can be sized to accommodate greater retention capacity. In the event of the system having been out of operation for a period of time, the chambers will be surcharged with the accumulated sewage. It is not necessary to remove this sewage by pumping, as the Iseki RediVac vacuum system will recover completely automatically.

The recovering vacuum works its way outward from the station emptying the chambers as it reaches them in turn. Please refer to the Iseki RediVac Video on materials handling capability where the situation is simulated and shown.

3. What is the maximum length of a vacuum sewer main?

The limiting factor when designing a vacuum sewer is not the distance from the collection station to the farthest sump but the maximum static lift from the lowest sump position back to the collection station. This static lift is again a figure that is subject to other considerations such as the terrain and the amount of flow in the pipe.

In general though, vacuum mains of length 2500 to 3000 metres are not uncommon, depending on the topography of the area to be served.

4. What equipment is in the vacuum station?

The equipment in the vacuum station will be sized to suit the flows entering the system, but in general will comprise of the following:-

One collection vessel, of either mild steel or glass fibre construction.

Two vacuum pumps either liquid ring or rotary vane type.

Two sewage discharge pumps.

One electrical control panel.

Probes and pressure switches mounted on the vessel to control the equipment.

Iseki RediVac Interface Valve Monitoring display panel.

5. What is the individual valve monitoring equipment?

It is a system that monitors the opening and closing of valves and is an invaluable trouble shooting tool. The display identifies exactly which valve may be malfunctioning and without any system shutdown, it can be checked and, if necessary, replaced for maintenance. The replacement would take about 15 minutes and causes no disruption to system users.

6. **Is a de-odorising unit required?**

It may be necessary to install such a unit particularly if the station is to be positioned close to other properties. A vacuum system discharges air through a single pipe exhaust and it is therefore simple to connect this exhaust to a de-odourising unit. Also, because the exhaust from the vacuum pumps is of a known definitive output, it is possible to size the de-odouriser accurately and to its maximum efficiency.

7. **What equipment failure would cause the system to fail?**

Each individual pump is sized to perform the required duty. It would therefore take the rare event of both vacuum pumps or sewage pumps failing at the same time to cause the system to fail. This is clearly no different to the situation with a conventional sewerage system, where in the event of a failure of both sewage pumps the system would cease to operate. Thereafter the system would make use of the retention capacity designed into the system.

If the water cooling unit was to fail on a system fitted with liquid ring vacuum pumps this would not cause a system failure as the vacuum pumps would continue to run safely. There would be a fall in the efficiency of the pumps as the service water temperature rose, causing the pumps to run for somewhat longer time than in normal operation.

The station telemetry will raise the alarm within minutes of a problem occurring.

Following reinstatement after a failure, the system will recover to normal operation entirely automatically.

8. **Is a stand-by generator required for a vacuum sewerage system?**

The answer to this depends upon the reliability of the mains electrical supply to the collection station. If, in a particular project, it is expected that power failures will be of a duration shorter than a recommended four hours then stand-by generation will not be required as the system will be designed with retention built in, in excess of this period to enable the facilities to remain useable.

If it is envisaged that longer power failures may occur, then other options need to be considered. These could be the inclusion of stand-by generation or the enlargement of collection sumps to increase the retention time available, or the number of collection sumps could be increased.

Operation & Maintenance

1. **What is the approach to maintenance etc within the vacuum station?**

The vacuum vessel requires no maintenance other than external painting. For this reason, no stand-by vessel is offered or needed. The two vacuum pumps are each sized to be able individually to perform the duty required and in the event of one failing or being maintained, the other pump will operate the system. This also applies to the sewage discharge pumps.

In general then, the vacuum station requires no more maintenance than a conventional pumping station.

2. **What equipment failure would cause the system to fail?**

As stated above, the pumps are sized so that each can perform the required duty. It would therefore take the rare event of both vacuum pumps or sewage pumps failing at the same time to cause the system to fail. This is clearly no different to the situation with a conventional sewerage system, where in the event of a failure of both sewage pumps the system would cease to operate.

Thereafter the system would store the effluent within the sewer network as previously described.

If the water cooling unit was to fail on a system fitted with liquid ring vacuum pumps it would not cause a system failure as the vacuum pumps would continue to run safely. There would be a fall in the efficiency of the pumps as the service water temperature rose, causing the pumps to run for a somewhat longer time than in normal operation.

The station telemetry will raise the alarm within minutes of a problem occurring.

Following reinstatement after a failure, the system will recover to normal operation entirely automatically.

3. Are blockages encountered in vacuum sewers?

This is an extremely rare occurrence. The sewage is moved through the vacuum sewers at high velocities; up to 6 metres per second in the form of a foamed ‘plug’. This makes the pipework self-cleaning. This, coupled with the fact that the system’s vigorous action breaks up solids, means that blockages almost never occur.

4. Is the vacuum main prone to damage and, if so, what procedures are to be followed to locate the fault?

If the recommendation regarding the use of high density polyethylene pipe with electro-fusion fittings is followed, then the vacuum main is not prone to damage as this produces an extremely strong and resilient integrated line. The only way that this is likely to be damaged is by unlawful or careless excavation. In the event of this happening, the telemetry alarm will then be raised and the maintenance operative will quickly be able to isolate which line has been damaged. It will then be a simple matter to locate the position of the excavation that has damaged the pipe. Location of any damage can be achieved by use of Iseki RediVac’s monitoring system, by use of the marker/tracer tape or by simply looking to see if any holes have been dug in the vacuum sewer trench line.

If an interface valve should fail in the open position and cause the system vacuum to fail, the individual valve telemetry will register this and the maintenance operative will instantly be able to locate the fault and rectify it.

In the very unlikely event of a leak or blockage developing in a vacuum main from a cause other than excavation, then the method of locating the leak is as follows:

- Firstly, each main is shut down in turn at the station so that the main on which the fault lies is quickly ascertained. Next, by shutting the isolating valves it can be established on which branch of the main the fault lies.
- Then, using the Iseki valve monitoring system and a portable monitor, it is possible to determine between which two valves the fault has occurred. In practice, this distance is unlikely to be much more than about fifty metres. The benefit of using the valve telemetry system in this diagnostic mode is that the number of isolation valves on the system can be kept to a minimum.
- The precise location of a blockage is discovered by removing the downstream valve and inserting flexible rods to identify the point of blockage. After identifying this point, a repair can be carried out as with a conventional sewerage system, but this is simpler on a vacuum system because the depth of the main is minimal and polyethylene pipe is very easily and quickly repaired using electro-fusion couplings.
- Because the existence of a fault would be immediately brought to the attention of the maintenance authority via the telemetry , the fault could be quickly repaired and not remain undiscovered, leaking pollution into the surrounding soils as can happen with a conventional system.

As part of the training offered by Iseki RediVac to the client’s maintenance operatives, the above procedures are fully described and demonstrated in detail.

APPENDIX

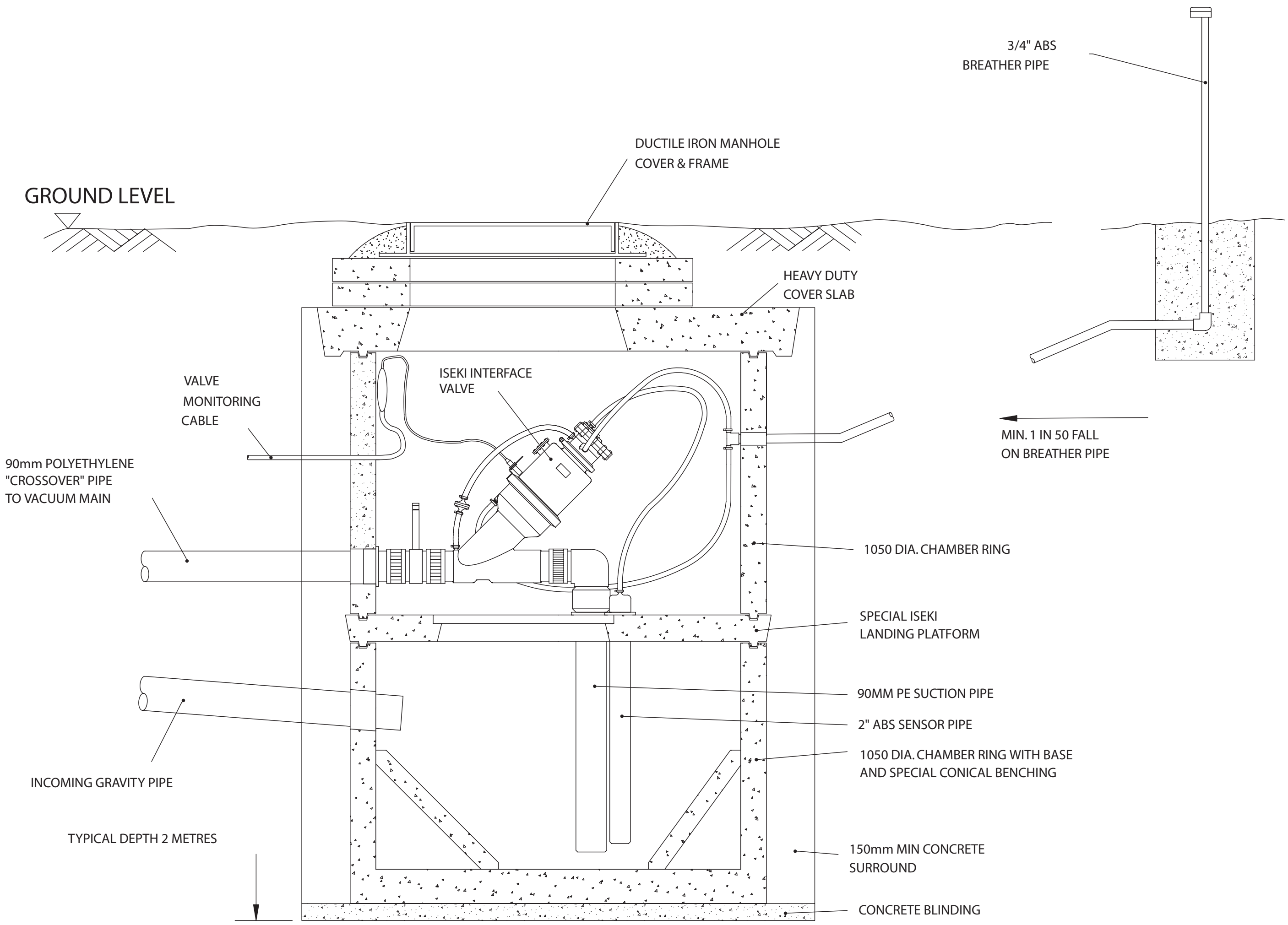


Fig. 5 Typical Concrete Valve Chamber

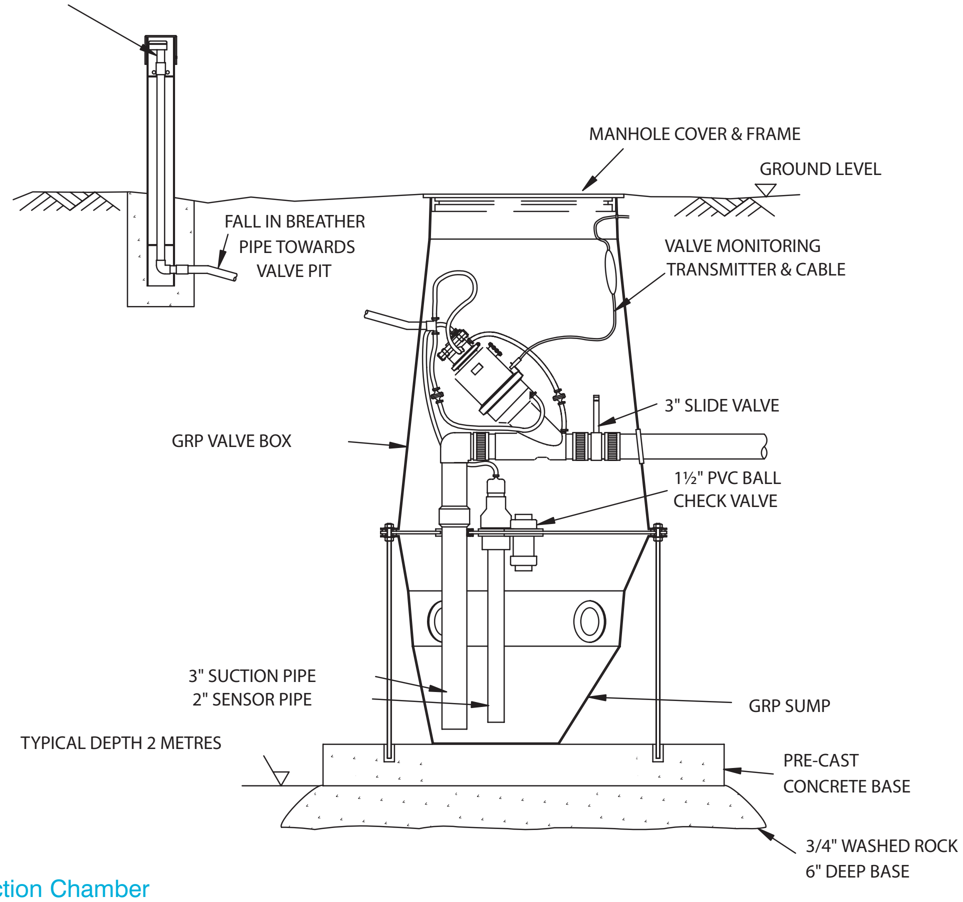
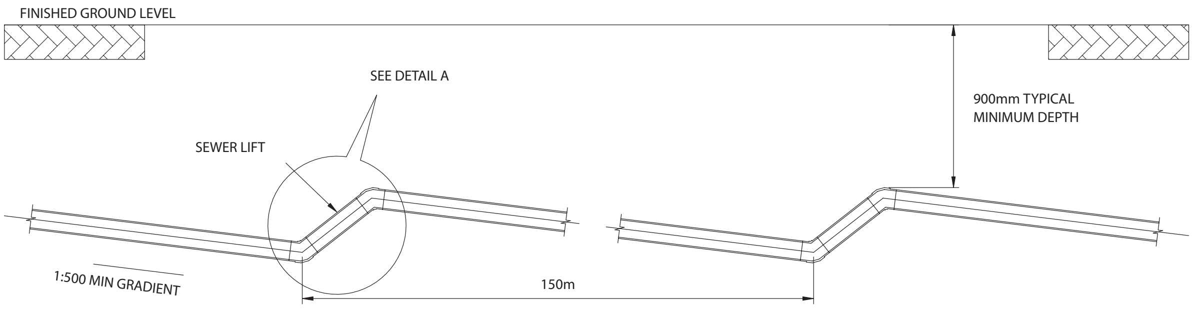
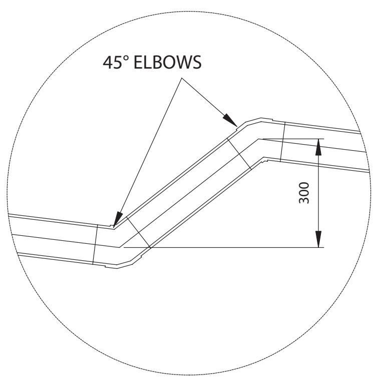


Fig. 6: GRP Collection Chamber



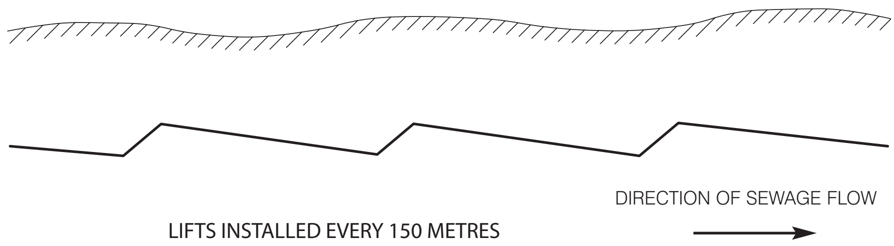
TYPICAL VACUUM SEWER PROFILE



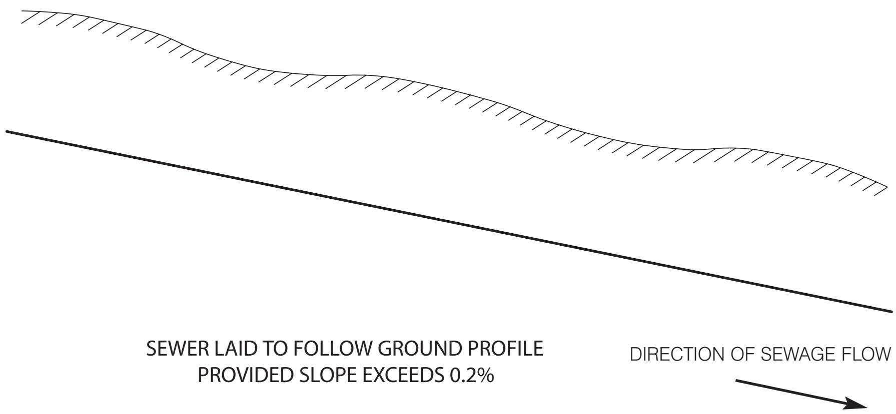
DETAIL A

Fig. 7: Typical Sewer Profile and Invert Lift Detail

FLAT GROUND TRANSPORT



DOWNHILL TRANSPORT



UPHILL TRANSPORT

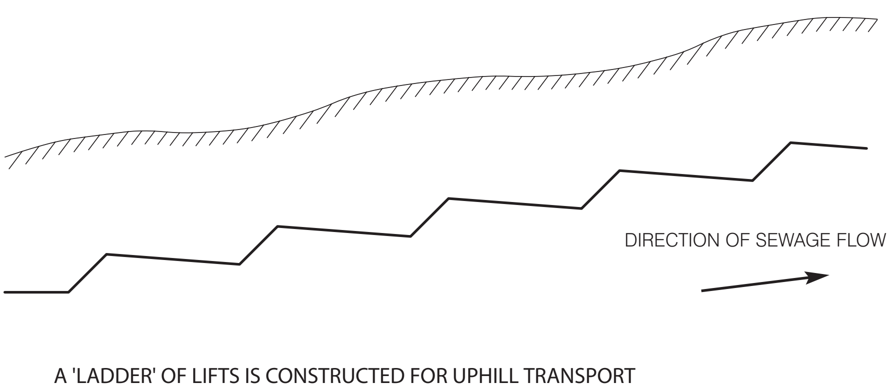


Fig. 8: Typical Vacuum Sewer Profiles

Iseki Vacuum Systems Limited
High March, Daventry,
Northants NN11 4QE
Tel: +44 (0)1327 878777
Fax: +44 (0)1327 315232
sales@iseki-vacuum.com
www.iseki-vacuum.com