VacCalc

Help and Operating Instructions

Overview

The programme has been created to allow the user to prepare a design for a vacuum drainage system. Vacuum drainage systems vary slightly from manufacturer to manufacturer so this design should be considered as a generic design to allow the preparation of contract documentation. The final vacuum drainage design should be prepared by the selected contractor based upon actual equipment proposed for the installation. The programme is set up to allow the user to input foul drainage flows based on the number of people connected to the vacuum collection chambers. The number of buildings connected to each collection chamber will depend upon the size and type of buildings served by the drainage network.

A vacuum system shall consist of a number of gravity drains leading to vacuum collection chambers, vacuum interface valves, vacuum sewers, a vacuum vessel, vacuum generators and vacuum discharge pumps. The vacuum is maintained in the network by the central vacuum generators and the vacuum vessel.

The waste water flows by gravity from a building to the nearest vacuum collection chamber. The wastewater builds up in the vacuum collection chamber until it reaches a predetermined level, the interface valve then opens for a set period of time and the wastewater and some air is drawn into the vacuum piping network. The vacuum piping is laid in a saw tooth profile and the wastewater moves along the pipe until pipe friction causes wastewater and air separation and the wastewater comes to a halt. The wastewater will then fall by gravity to the lowest point in that particular section of the network. As other interface valves open in the network the wastewater will be gradually drawn to the central vacuum vessel.

The vacuum vessel is a closed container and over time will be partially filled with incoming wastewater. Once the wastewater reaches a fixed level within the vessel a discharge pump will be activated and the wastewater in the vessel will be discharged into the pressure main to the final discharge point. Once the wastewater level in the vessel falls to a predetermined low level the pump

The vacuum generators remove the air from the vacuum vessel and the connected vacuum piping network to create the working vacuum within the network. The evacuated air is exhausted to atmosphere via a bio filter to minimize odour.

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Worksheet tabs

The programme contains a number of worksheet tabs, these are named 'Help', 'Cover sheet', 'Foul', 'Pipe Length', 'No. of persons', 'Pumping Main', 'Pump Suction' and 'Vacuum Station'

'Help' tab -   'Help' tab contains the Help and Operating instructions for the programme

'Cover Sheet' tab -   The 'Cover Sheet' tab contains the cover sheet template for the programme print out.

'Foul' tab -   The 'Foul' sheet tab contains the main part of the programme.

'Pipe Length' tab -   The 'Pipe Length' sheet tab contains a sub programme that allows the user to input details of all of the pipes in the network and calculate the total network volume.

'No. of persons' tab -   The 'No. of persons' sheet tab contains a sub programme that allows the user to calculate the number of persons in any particular building connected to the network.

'Pumping Main' tab -   The 'Pumping Main' sheet tab contains a sub programme that allows the user to calculate the size of the pumping main.

'Pump Suction' tab -   The 'Pump Suction' sheet tab contains a sub programme that allows the user to calculate the size of the pump suction main.

'Vacuum Station' tab -   The 'Vacuum Station' sheet tab contains a sub programme that allows the user to calculate the size of the Vacuum station pumps.

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Inputting data   **Only place data in boxes marked in blue**

Pipe reference No. -   The user should select a reference numbering system to suit their own requirements. The pipe reference number is a text field allowing a combination of letters and numbers to be input. Pipe reference numbers must be input before adding extra rows.

Pipe material -   The pipe material for each branch can be selected from a drop down menu. For vacuum systems it is normal for HDPE or uPVC piping to be used.

Pipe diameter -   The pipe diameter is selected from a drop down menu. The pipe sizes offered are dependant on the pipe material selected.

Pipe capacity -   The pipe capacity is automatically generated by the programme. The pipe capacity is dependant on the pipe size selected.

Index length of pipe -   As with pressure systems vacuum systems are sized based upon the index length of the piping network. The index length is the piping length from the furthest vacuum collection chamber to the central vacuum station. A line in the programme should be created for each piping section in the total index length. No more than 500 metres of 110mm diameter pipe should be included in any vacuum branch including the index length. This is necessary to maintain a good

The user should input the section length in metres. A new section length (line in the programme) should be created after each branch connection from a vacuum collection chamber or at a change of pipe diameter. The maximum length of the index piping run is 4575 metres. No system should be created where the index pipe run exceeds 4575 metres.

Air to liquid ratio No. -   The air to liquid ratio number is automatically generated by the programme. The air to liquid ratio is based on the total length of the index length. The minimum air to liquid ratio is 5 and the maximum is 11.

Initial vacuum generator capacity -   The initial vacuum generator capacity is generated automatically by the programme. There are two values given for the generator capacity, the first figure is given for systems that will not be adopted by a local authority and the second is for a system that will be adopted by a local authority. Adopted systems are likely to require a minimum vacuum generator capacity of 250 cubic metres per hour. The initial vacuum generator capacity will only be calculated by the programme after the flow in the pipe run has been input. Before the initial vacuum generator capacity can be calculated the total volume of the vacuum network must be calculated using the 'Pipe length' tab. (See further details below)

Vessel operating capacity -   The vessel operating capacity is equal to the wastewater flow that can be expected to arrive at the central vacuum station in 3 minutes. This time period is used to limit the number of discharge pump starts to 5 per hour per pump. This is based upon 2 discharge pumps with alternate starts. The vessel operating capacity is automatically calculated by the programme. The vessel operating capacity will only be calculated by the programme after the flow in the pipe run has been input.

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Total vessel capacity - The total vessel capacity is automatically calculated by the programme. The total vessel capacity is generally taken to be 3 times the vessel operating capacity. The minimum volume of the vessel should be not less than 1500 litres. The reason for this minimum capacity is the difficulty of manufacturing vessels of a smaller capacity and the installation of the control equipment. Again the total vessel capacity will only be calculated by the programme after the flow in the pipe run has been input.

Initial evacuation time - The intial evacuation time is automatically calculated by the programme. The evacuation time should be between 1 and 3 minutes. The programme is designed to provide a final evacuation time of 3 minutes. The initial evacuation time can be any number of minutes but the programme will automatically calculate a final evacuation time of 3 minutes irrespective of the initial evacuation time.

Final vacuum generator capacity - The final vacuum generator capacity is generated automatically by the programme. The final capacity is based on an evacuation time of 3 minutes. There are two different capacities one based on a private vacuum system and one based on an adopted system where the adopting authority requires a minimum generator capacity of 250 cubic metres per hour.

Peaking Factor - The peaking factor should be selected from the drop down menu. BS EN 752-4:1998 states that a peaking factor of upto 6 should be used. The peaking factor gives the relationship between the average flow and the peak flow. The average flow is based on the quantity of water used by a person during an average day and a figure of 200 litres per day is widely used. For specific situations such as schools, restaurants etc. other figures can be used as shown in the 'connection from' drop down list. (See below). The DWF (dry weather flow) peaking factor is a constant 6 times the average flow. The other peaking factor types are based on a factor that reduces as the population is increased. The named formulas are based on factors that are calculated on populations that are calculated in 1000's. The results provided by the formulas vary slightly from one to another and if possible the peaking factor to be used should be agreed with the client or the adopting authority. As all of the factors are based on probability theory none can be said to be more

Type of use - The type of use should be input by the user and is selected from the drop down menu. Generally the 'intermittent' use should be selected if the system is for mixed use or housing. 'Frequent' use should only be selected if the whole vacuum system is serving a school, restaurant, hotel or hospital. 'Congested' use should only be use for a system serving only public toilets, changing rooms or showers. 'Special use' should only be used for laboratories.

Use factor - The use factor is automatically generated by the programme and is based on the type of use selected.

Connection from - The 'Connection from' drop down menu should be used to select the location of the system. Generally the 'Main sewer' option should be used as this is for a general mixed use system. If the system only serves one building or one type of building then one of the alternative options can be used. **Do not use different options on the same system.**

Daily flow per person - The daily flow per person is automatically generated by the programme and varies depending on the type of 'connection from' selected.

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Average flow - The average flow is automatically calculated by the programme and varies depending on the type of 'connection from' selected.

Peak flow - The peak flow is automatically calculated by the programme. The peak flow is only calculated once the number of persons in the branch has been input.

No. of people in connection - The number of people in the connection should be input by the user based on the number of people connected to the specific collection chamber. If a building has an unknown number of occupants, the 'No. of persons' tab should be used to calculate the likely number of persons based on the number of wc's in the building. (See No. of persons below)

Total No. of people - The total number of people is automatically calculated by the programme. The total number of people is the sum of the people in each branch connection.

Sundry flows - Any sundry flows should be input by the user into the branch in which the flow occurred. Sundry flows should consist of continuous flows from a non domestic source. As vacuum systems must be completely watertight and thoroughly tested no allowance should be made for infiltration.

Total flow in connection - The total flow in a connection is automatically calculated by the programme and consists of the sum of the peak flow in the connection and any sundry flow in the connection.

Total sundry flows - The total sundry flows is automatically calculated by the programme and consists of the sum of the sundry flows in each branch.

Total flow in run - The total flow in the run is automatically calculated by the programme and consists of the sum of the peak flow in the index run plus the total sundry flows in the index run.

Creating an additional branch

To create an additional branch press "Control+C" this activates a macro which will add a new line below the existing line. To add a further line press "Control+C" again.

Removing a branch

To remove a branch press "Control+D" this activates a macro which will remove the last branch. To remove a further branch press "Control+D" again.

Pipe length tab

To calculate the total volume of the vacuum network the user must select the 'Pipe length' tab and fill in the user input columns. All the pipe lengths should be input including the index length. Once all the lengths have been input the programme will automatically insert the final volume in the correct formula in the 'foul' tab, allowing the final vacuum generator capacity to be calculated.

Pipe material - The pipe material for each branch can be selected from a drop down menu. For vacuum systems it is normal for HDPE or uPVC piping to be used.

Pipe diameter - The pipe diameter is selected from a drop down menu. The pipe sizes offered are dependant on the pipe material selected.

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Length of pipe - The pipe length shall be input by the user. The pipe lengths can be input as individual lengths or as groups, but each length or group of lengths must be of a common diameter.

Total pipe volume - The total pipe volume is automatically calculated by the programme.

No. of persons tab In order to assist in calculating the total number of persons likely to be present in a building the 'No. of persons' tab should selected and the following data should be input. Once the 'project' and 'location' data has been input the following data should be input.

Type of building The type of building should be selected from the drop down menu.

No. of WC's or male WC's - For the majority of the buildings it will only be necessary to fill in the first 'No. of WC's' box but in buildings such as swimming pools, public houses, restaurants etc.it will be necessary to input both the male and female WC numbers. In the case of schools the total number of WC's both male and female should be placed in the first input box.

No. of WC's or female WC's - As explained above the number of female WC's only needs to be input in cases where the WC provision for males and females are different. In cases where the provision for males and females are the same only the first box needs to be input. Placing a figure in the second box will return a figure of zero in these cases.

Total No. of people - The total number of people is automatically calculated by the programme. The figure stated should be transferred to the relevant column in the 'foul' worksheet.

Vacuum station tab The vacuum station tab allows the user to select suitable discharge pumps for the system. The programme automatically selects a suitable flow rate for the pumps and the user only has to calculate the pump head required.

Vacuum station Reference - The user should input the vacuum station reference. This is a free text input box.

Pump suction level - The user should input the pump suction level. The pump suction level is the level at which the pump cuts out.

Maximum delivery level - The user should input the maximum delivery level. The maximum delivery level is the highest point in the discharge line and is not necessarily the end point of the discharge line.

Number of pump starts - The user should input the proposed number of pump starts per hour.

Number of operating pumps - The user should input the number of operating pumps.

Pumping main tab The user should select the pumping main tab to calculate the discharge main friction loss and residual head. The result of this calculation is automatically input into the pumping station tab in order to calculate the total pump head required.

Pipe Reference No. - In the pipe reference number column the user should input the start and end numbers for the pipe section being described. These numbers should match the numbers shown on the drawing that indicates the pumping network.

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Pipe Material - The pipe material for the section of the pump discharge network should be selected from the drop down menu. The progamme allows the user to select a different pipe material for each section of the system. This can be particularly useful when checking an existing system or a when the user is adding to or modifying an existing system. Once the pipe material has been selected the programme automatically selects the correct friction coefficient for the material.

Pipe size - The pipe size for the section of the pump discharge network should be selected from the list that is presented to the user. The list presented will be automatically selected by the programme based on the pipe material that is selected. The programme will automatically select an internal pipe diameter based on the nominal diameter that is selected by the user. The programme uses the internal pipe diameter to calculate the pipe friction and water velocity.

Pipe length - The user should input the length of the section as measured from the network drawing.

Fittings Length - The fittings length is automatically generated by the programme and represents the equivalent length of each fitting multiplied by the number of each type of fitting. The

Total pipe Length - The total pipe length is automatically generated by the programme and represents the total of the measured pipe length and the equivalent length of the fittings and valves

Head Loss - The head loss is automatically generated by the programme and represents the loss of head due to friction along the section of pipe and through any valves and

Total Head Loss - The total head loss is automatically generated by the programme and represents the sum of the head losses in each section of the pump discharge network to that point.

Static Head Required - The static head required should be input by the user for the first section only. The programme will show the static head required for all other pipe sections.

Type of elbow - The user should select the type of elbow or bend from the drop down list. Mitre fabricated bends will only be necessary if larger diameter glass fibre bends are required.

Number of elbows - The user should input the number of elbows in the section of the network.

Type of Tee - The user should select the type of tee from the drop down list. Where a increasing size tee is required a standard tee should be specified together with an enlargement that

Number of tees - The user should input the number of tees in the section of the network.

Enlargements & Contractions - The user should select the type of enlargement from a drop down list. The 3/4, 1/2 and 1/4 figures represent the increase in pipe diameters. For example if a 150mm diameter pipe increases to 200mm diameter this will be represented by a 3/4 enlargement.

Type of valve - The user should select the type of valve from the drop down list. A globe should not be proposed unless flow control is required and under no circumstances should be proposed in a sewage discharge pipe.

Number of valves - The user should input the number of valves in the section of the network.

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Number of gate valves - The user should input the number of gate valves in the section of the network. Where ball valves are specified these should be considered to be similar to gate valves and input as such for head loss purposes.

Number of check valves - The user should input the number of check valves in the section of the network.

Residual Head Required - The user should input the residual head required in the first pipe section. The programme will indicate the residual head required for all the other pipe sections. The residual

Total Head Required - The programme automatically generates the total head required. This figur represents the minimum pump head required to operate the pumped discharge network correctly. Once the total head has been calculated the user should return to the vacuum station tab where the programme will have automatically input the required combined friction and residual head figure.

Total head required - The programme will automatically calculate the total head required.

Pump Suction tab The user shall select the pump suction tab to calculate the head loss in the pump suction main. The result of this calculation shall automatically be input into the vacuum station

Pipe Reference No. - In the pipe reference number column the user should input the start and end numbers for the pipe section being described. These numbers should match the numbers shown on the drawing that indicates the suction piping.

Pipe Material - The pipe material for the section of the pump suction piping should be selected from the drop down menu. The progamme allows the user to select a different pipe material for each part of the suction arrangement. Once the pipe material has been selected the programme automatically selects the correct friction coefficient for the material.

Pipe size - The pipe size for the section of the pump suction arrangement should be selected from the list that is presented to the user. The list presented will be automatically selected by the programme based on the pipe material that is selected. The programme will automatically select an internal pipe diameter based on the nominal diameter that is selected by the user. The programme uses the internal pipe diameter to calculate the pipe friction and water velocity.

Pipe length - The user should input the length of the section as measured from the network drawing.

Fittings Length - The fittings length is automatically generated by the programme and represents the equivalent length of each fitting multiplied by the number of each type of fitting. The figure also includes the equivalent length and number of any gate valve included in the length.

Total pipe Length - The total pipe length is automatically generated by the programme and represents the total of the measured pipe length and the equivalent length of the fittings and valve included in the section.

Head Loss - The head loss is automatically generated by the programme and represents the loss of head due to friction along the section of pipe and through any valve and fittings.

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Total Head Loss - The total head loss is automatically generated by the programme and represents the sum of the head losses in each section of the pump suction arrangement to that point.

Static Head Available - The static head available should be input by the user for the first section only. The programme will account for the static head available for all other pipe sections. The static head available is the difference in level between the outlet at the base of vacuum vessel and the centreline of the pump.

Total head remaining - The programme will automatically calculate the remaining head available after all the piping losses have been deducted. The final figure after all the sections of suction piping have been input will be automatically input into the 'Vacuum Station' calculation tab in the appropriate location.

Vacuum station tab The user shall select the 'Vacuum Station' tab to calculate the pump details for the system.

Vacuum Station Ref. - The user shall input the vacuum station reference, which is a free text input.

Inflow - The programme will automatically calculate the effluent inflow.

Proposed Discharge - The programme will automatically calculate the proposed discharge rate of each pump.

Pump Suction level - The user shall input the pump suction level, which is the centreline of the discharge pump inlet.

Maximum delivery level - The user shall input the maximum delivery level. This level should be the highest level in the discharge line, which may not be the discharge point of the delivery main.

Static Head Required - The programme will automatically calculate the static head required.

Friction Head Required - The programme will automatically calculate the friction head required. The value will include the required residual head.

Total Head Required - The programme will automatically calculate the total head required.

Number of starts - The user shall input the proposed number of starts per hour. The Number of pump starts shall not exceed the number recommended by the proposed pump manufacturer.

Number of pumps - The user shall input the proposed number of pumps. The number of pumps shall be the number of operating pumps and shall not include any standby pumps that only operate if they are manually switched into operating mode.

NPSH available in vessel - The programme will automatically calculate the NPSH available in the vacuum vessel.

Head loss in piping - The programme will automatically calculate the head loss in the suction. piping.

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NPSH available at pump - The programme will automatically calculate the NPSH available at the pump.

Maximum NPSH available at pump - The programme will automatically calculate the maximum NPSH available at the pump. This value gives a factor of safety on the NPSH available at the pump.

Minimum operating volume of vessel - The programme will automatically calculate the minimum operating volume of the vacuum vessel.

Actual number of pump starts per hour - The programme will automatically calculate the actual number of pump starts per hour for each pump.

Proposed pump manufacturer - The user shall input proposed pump manufacturer.

Proposed pump type - The user shall input the proposed pump type.

Proposed pump duty - The user shall input the pump duty after consulting the pump manufacturer's catalogue or website. When selecting a suitable pump the user must ensure that the NPSH (Net Positive Suction Head) requirement of the pump is less than the NPSH available. Because the pump is drawing water from a vessel under vacuum the NPSH available will be much less than that normally available. For this reason the pump should be located as close as possible to the vacuum vessel with a minimum number of bends and valves between the vessel and the pump. The pump should be located at or below the level of the vessel.

Proposed electrical load - The user shall input the proposed electrical load after consulting the manufacturer's catalogue or website.

Creating an additional section

To create an additional section press "Control+C" this activates a macro which will add a new line below the existing line. To add a further line press "Control+C" again.
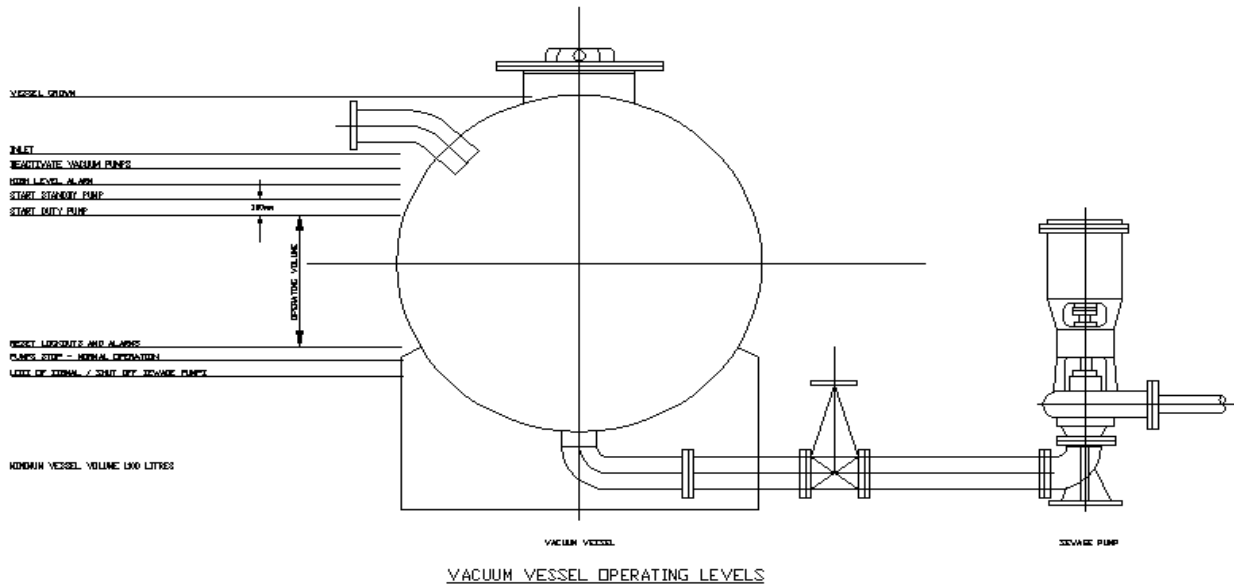
Removing a section

To remove a section press "Control+D" this activates a macro which will remove the last section. To remove a further section press "Control+D" again. Do **not** remove the first two lines of any section.

Setting the print area

To set the print area of the sheets press "Control+P" this activates a macro which will set the print areas ready for printing.

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Typical vacuum vessel and discharge pump arrangement

VESSEL CROWN

INLET
REACTIVATE VACUUM PUMPS
HIGH LEVEL ALARM
START STANDBY PUMP
START DUTY PUMP

RESET LOCKOUTS AND ALARMS
PUMPS STOP - NORMAL OPERATION
LOSS OF SIGNAL / SHUT OFF SEWAGE PUMPS

MINIMUM VESSEL VOLUME 1900 LITRES

VACUUM VESSEL

SEWAGE PUMP

VACUUM VESSEL OPERATING LEVELS

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Typical vacuum piping arrangement

ELEVATION

PLAN

END VIEW