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Highway or waterway?
1. Technical description

1.1. General information

The Stormbox system is designed to manage rainwater by retention and non-pressure distribution and infiltration into the ground. Rainwater collected from building roofs and industrial facilities is directed through gutters, discharge pipes and sewage pipes into a chamber with a settling tank, and then to infiltration boxes. Rainwater collected from other hard surfaces, such as roads, car parks, streets and green areas, run through linear drainage systems, storm inlet and pre-treatment devices (e.g. settling tanks and hydrocarbon separators) into the Stormbox system.

The progress of civilisation has meant that, particularly in urban agglomerations, rainwater from hard, impervious surfaces (roofs, streets, car parks) flows directly to rainwater drainage systems or combined sewage systems. Where runoff is directed to water treatment plants, it causes additional load (decreased efficiency) and increased treatment costs. Directing runoff to sewage systems leads to an increase in pipe dimensions (unnecessary overdimensioning), and consequently to significantly higher pipeline installation costs. It is estimated that approx. 80% of runoff ends up in rainwater drainage systems and water courses.

Why is rainwater infiltration such a good idea?

Water is one of those natural resources that have no substitute. In some countries conditions with regard to access to water, annual amount of precipitation, very large fluctuations in temperature and amount of rainfall are significantly worse than in other countries. Inland fresh-water waters (rivers, lakes, reservoirs) constitute approx. 3% of the country's area. Fluctuating climate conditions and weather anomalies cause an excess of water during heavy storms or snow meltdowns, and water deficits during periods of drought.

Modern runoff drainage planning involves decreasing and slowing down the runoff from impervious surfaces. The progress of urbanisation leads to the destruction of natural water flow paths. Hence the increased significance of the designer, who can plan alternative runoff paths by building underground retention and infiltration systems. It is recommended that rainwater should be collected in the areas where it falls, and then allowed to infiltrate into the ground or stored, as required. Redecking to the greater depths of subsurface layers, rainwater rejuvenates the groundwater resources.

The situation could be improved by the construction of retention and retention-infiltration tanks. Appropriate management of rainwater in its catchment area may also alleviate the consequences of potential flooding.

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Rainwater retention and infiltration

The basic Stormbox system kit includes:

1.2. Basic technical information

- protection of ground and surface waters.
- drainage systems may contribute to the
- improves the condition of urban open waters,
- helps to avoid overdimensioning of rainwater
- increases the efficiency of water treatment
- compensates for the adverse impact on
- lowers outflow rate, flattens flow peaks,
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6. The structure of the Stormbox

6.1. Infiltration box

Stormbox infiltration boxes are cuboid, with 5 faces (no bottom). Inside the box are vertical supports, clipped to appropriate holes in the ground plate or in the box underneath. In the top part of the box are 2 inspection openings, for constant access to the inside of the box, and for bleeding the air out. There are 2 inspection openings in the front and back walls and 1 inspection opening in each of the side walls.

All the side walls of the box have openings to connect the rainwater drainage system, ventilation pipes, and wash and inspection pipes, diameters d n 110, 125 and 160 mm, and in the top wall d n 110, 125, 160 and 200 mm. An adaptor can be used to connect pipes 200 – 500 mm in diameter.

5. Scope and conditions of use

The Stormbox kit is useful in areas with low groundwater levels, in light and permeable soils and in cohesive soils (low permeability) combined with a gravel pack to increase the rate of infiltration.

The system may also be used to store water when isolated from the surrounding soil, for example for using a geomembrane.

The following conditions should be met when using the Stormbox kit:

- the gutter system should be connected to the settling chamber and the infiltration boxes using standard socket and spigot joints, see dimension of the Stormbox infiltration and retention box; the gutter system should be connected to the settling chamber and the infiltration boxes using external sewage PVC-U or PP pipes and fittings compliant with PN-EN 1401-1, PN-EN 13476-2 or PN-EN 1852-1, and standard Progess PP-R pipes compliant with PN-EN 1264-7. Water is conducted to boxes wrapped with polypropylene filter fabric;

5.1. Installation parameters for areas subject to traffic loads

- minimum depth of the cover layer over infiltration boxes: 0.8 m;
- ground compaction around the boxes: min. 97% Standard Proctor Density;
- maximum number of box layers: 6 for HGV traffic load (box height max. 1.82 m), 10 for car traffic load (box height max. 3 m);
- depth of the bottom layer: up to 4.5 m. If boxes are to be placed at a lower level, please contact Pipelife for an analysis of the ground conditions and expected loads.

5.2. Installation parameters for green areas

- minimum depth of the cover layer over infiltration boxes: 0.4 m;
- ground compaction around the boxes: min. 95% Standard Proctor Density;
- maximum number of box layers: 10 (box height max. 3 m);

Elements of the rainwater distribution and infiltration system, i.e. the settling chamber, the sewage pipes and the infiltration boxes, are connected using standard socket and spigot joints.
Special vertical and lateral reinforcements of the Stormbox ensure very high durability, but take up very little space – the box's storage capacity is as high as 95.5%.

Openings in the sides of the box are 110 mm, 125 mm and 160 mm in diameter. The diameters are suitable to connect the plain end of a PVC-U sewage pipe, manufactured in accordance with PN-EN 1401-1, PN-EN 13476-2, or a structural Pragma PP-B pipe, manufactured in accordance with PN-EN 13476-3, or other similar pipes.

The box and the ground plate are designed in such a way that they may be cut in half widthwise. Net water capacity of a half-box is 103 dm³.

Dimensions of the Stormbox infiltration and retention box

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>1200 mm</td>
</tr>
<tr>
<td>Width</td>
<td>600 mm</td>
</tr>
<tr>
<td>Height</td>
<td>311 mm</td>
</tr>
</tbody>
</table>

The openings are secured with open-work covers. Before connecting the pipes the covers must be cut, adjusting the size of the opening to the connected pipe.

6.2. Ground plate

The ground plate is connected to the box. It is only used in the first layer of boxes.

The dimensions of the ground plate (L x W x H) are 1200 x 600 x 20 mm. The ground plate has catches which clip onto the vertical tubes of the box.

Boxes are connected to each other and the ground plate using clips. Ground plates may also be used to connect boxes together. Since they are rectangular made up of two symmetrical squares, they may be used to connect boxes arranged side by side as well as a row of boxes.

Connections using ground plates is, however, only mandatory and does not eliminate the need to use clips.

Dimensions of the Stormbox infiltration and retention box

}[Image -10x-9 to 457x604]
[Image 873x295 to 1362x563]
[Image 1372x296 to 1632x422]
[Image 542x56 to 671x226]
7. Surface area of openings

7.1. Total surface area of openings
The average area of Stormbox openings is very substantial and amounts to approx. 50% of the box surface.

7.2. Surface area of side wall openings
The area of the openings in the side walls is very large and amounts to approx. 50% of the box surface, creating very favourable conditions for the infiltration of rainwater.

The generous surface area of openings, particularly in the side walls of the boxes, is significant, since with time the rate of infiltration naturally decreases, approaching a limit value which depends on soil properties.

7.3. Surface area of ground plate openings
The decrease in the rate of water infiltration through the ground plate depends mainly on the type of soil underneath and on the amount of sediment collecting at the bottom of the infiltration boxes.

The openings in the ground plate have a large surface area (approx. 43%), ensuring very favourable conditions for the infiltration of rainwater.

8. Box marking

The construction of the Stormbox with the large surface area of openings at the bottom and in the side walls ensures the most favourable conditions for the infiltration of rainwater.

The raised Stormbox markings are created in the process of high pressure injection molding. The markings should comprise at least:

- manufacturer’s logo: PIPELIFE
- product name: Stormbox
- material symbol: PP
- manufacturing date, year and month, e.g. 2008.07
- box capacity: Volume 216 Liter

6.3. Clips
They are made of PP-B polypropylene and used to connect ground plates, ground plates to boxes, and boxes themselves, horizontally and vertically. The connection points on the ground plate and on the box are marked with the word “CLIP”. 12 clips are needed to connect a ground plate to a box or two boxes vertically. When connecting boxes alternately (brick bond arrangement), 8 clips are needed to connect them vertically.
9. Load resistance

Pipelife Stormbox infiltration boxes have undergone load resistance analysis using the Finite Elements Method (FEM) and laboratory tests using a load resistance testing machine at Pipelife Nederland B.V., the Netherlands. The tests have determined that the Stormbox is resistant to a short-term vertical load of 579 kN/m² and a lateral lengthwise load of 134 kN/m². The test results confirm the high load resistance of the boxes.

The boxes comply with load resistance requirements of standard BRL 52250 (the Netherlands), which specifies a 3 days vertical load of 200 kN/m² and a lateral load of 85 kN/m². The high load resistance and quality of the boxes has been confirmed by the Kiwa N.V. KOMO Certificate.

10. Transport and storage

Boxes are stored and delivered on wooden pallets 1.2 m x 1.2 m, in 8 layers (height 2.4 m). Boxes should be loaded and unloaded using forklift trucks. Boxes may be stored outdoors, on a flat and even area. In case of outdoor storage for a period longer than 12 months they should be stored in shade or, if necessary, covered with light-coloured, opaque tarpaulin.

Due care should be taken when loading and unloading, especially at temperatures below 5ºC. The Stormbox system elements should be protected against damage and deformation at each stage, from storage, through transport, to the place of installation.

Rainwater from a building roof or another drain ed surface (e.g. a yard) is directed through gutters and discharge pipes to a settling chamber where mechanical impurities are separated, sent onto septic tanks or to infiltration boxes wrapped in filtration mats, so that water may infiltrate into the ground. The infiltration boxes are combined horizontally and vertically into modules, whose size depends on the requirements (the module size mainly depends on the size of the drained area and the degree of soil permeability). In order to accelerate the filling of the system, the other end of the box set should be ventilated by means of a PVC-U sewage pipe d n 110 mm (160 or 200 mm), which should be connected to the hole in the top plate of the box. A ventilation pipe with an air valve cover should extend above ground to the height of approx. 50 cm.

11. Installation guidelines

PVC-U or PP pipes and fittings (for external sewage systems) compliant with PN-EN 1401-1, PN-EN 13473-2 or PN-EN 1852-1 are used to connect the gutter system to the supply/settling chamber, the infiltration boxes and the ventilation chamber. When using structural PP-B Pragia pipes (compliant with AT/99-02-0752-03 and PN-EN 13476-3), adapters for PVC-U sewage pipes should be used.

DN/OD 400 and DN/OD 630 settling chambers are made of polypropylene (technical parameters compliant with the AT/2007-03-0096 approval). PRO 800 and PRO 1000 settling chambers are made of polypropylene (technical parameters compliant with the AT/2005-02-1538-02 and AT/2004-04-1717 approvals). The outlets of the setting chambers might be fitted with a device blocking impurities from entering the box set, e.g. self-cleaning steel filters.

Before the boxes are laid down, it is necessary to decide the points where inspection equipment will be inserted through manholes PRO 800, PRO 1000 and vertical inspection pipes, depending on the size of the system. The hole diameters make it possible to introduce cleaning equipment or CCTV into the box module through 6 openings (110, 160 mm) located on the side walls of the boxes and through the 2 openings on the top (110, 160 mm).
11.1. Diagrams of various Stormbox arrangements

Stormbox infiltration boxes may be arranged in the following configurations:

- Single box
- Row of boxes
- Double row (top view)
- Double row, several layers, brick bond arrangement (lateral and top view)
- Double row, several layers (lateral view)
- Stormbox units arranged in an alternating pattern

11.2. Sequence of tasks to be performed when installing a rainwater infiltration system

1. Dig a trench at least 40 – 50 cm wider than the width of the box module.
2. Remove any protruding stones from the bottom and lay down min. 10 – 15 cm of gravel bedding, grain size e.g. 8 – 16, 16 – 24 (30) mm, or a layer of coarse sand. Even out and compact the ground.
3. Leave the open-work covers from the connection points of the 160 mm supply pipes, 110 – 220 mm ventilation pipes and 200 mm inspection pipes.
4. Lay the ground plates on the geotextile and connect them together, using clips. The points where clips should be placed are marked with the word “CLIP”. Next, place the boxes on the ground plates, pushing them down. The vertical tubes in the boxes should clip onto the ground plates. Connect the boxes and the ground plates using clips. If applicable, lay subsequent layers of boxes, connecting them with clips vertically and horizontally.
5. Carefully wrap the geotextile around the boxes, leaving an overlap of 15 cm – 50 cm. At the inlets prepare star-shaped openings by making 8 cuts in the geotextile. Then insert approx. 20 of the supply pipes, so that the socket extends from the opening.
6. Connect the boxes to 160...
8 Install a ventilation pipe at the other end of the box set by connecting a PVC-U sewage pipe DN 110 mm (160 or 200 mm) to the socket of the pipe mounted in the top opening of the box. The ventilation pipe with an air valve cover should extend approx. 50 cm above ground. The pipe may also be used for inspections. For purposes of inspection and cleaning install 200 mm chambers above the boxes or 400, 630 mm inspection chambers at the end of the tank.

9 Fill the sides with 15 – 30 cm layers of gravel pack, grain size e.g. 8 – 16, 12 – 24 (30) mm, or with coarse sand. Even out and compact the ground. Adjust the ground compaction level to the expected loads.

Cover the boxes with a 10 – 15 cm layer of sand (without stones or other sharp-edged elements which might damage the geotextile or the boxes) and compact it.

To make an initial calculation of the necessary number of clips, regardless of the number of layers, use the following formula: number of boxes x = 14 pcs. Pipelife can calculate the exact number of clips for a given solution.

When conducting groundwork, laying out and assembling the boxes and the plastic pipes, observe standards PN-EN 1610, PN-ENV 1046.

To ensure adequate support for the boxes it is necessary to determine the technical properties of the materials used to fill in the trench, in particular the sidefill and its compaction. Geotextile parameters should be chosen based on the box arrangement and the expected loads. It is recommended that geotextile which comes in contact with gravel should have the tensile strength of over 8 kN/m and static puncture resistance (CBR) of over 1.2 kN.

<table>
<thead>
<tr>
<th>Properties</th>
<th>SF 37</th>
<th>TCM 250</th>
<th>TCM 300</th>
<th>T 225</th>
<th>T 275</th>
<th>HTS 200</th>
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</thead>
<tbody>
<tr>
<td>Tensile strength kN/m</td>
<td>8.5</td>
<td>7.6</td>
<td>9.6</td>
<td>9</td>
<td>11</td>
<td>8.5</td>
</tr>
<tr>
<td>Static puncture resistance (CBR) kN</td>
<td>1.275</td>
<td>1.61</td>
<td>2.47</td>
<td>1.6</td>
<td>2.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Dynamic puncture resistance (cone drop test) mm</td>
<td>33</td>
<td>22</td>
<td>21</td>
<td>26</td>
<td>24</td>
<td>20</td>
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<tr>
<td>Water permeability perpendicular to the surface m/s</td>
<td>5.1x10^-3</td>
<td>4.6x10^-2</td>
<td>2.5x10^-2</td>
<td>9x10^-2</td>
<td>7.8x10^-2</td>
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</tr>
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<td>Thickness under load</td>
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<td>200 kN/m²</td>
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<tr>
<td>EN ISO 9863-1</td>
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<td>0.35</td>
<td>2.7</td>
<td>2.1</td>
<td>3.4</td>
<td>2.5</td>
</tr>
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</table>

| Surface density g/m² | 125 | 250±25 | 300±30 | 190±19 | 220±22 | 150 | 150 |
| Colour | grey | white | white | grey | white | white | white |
| Geotextile type | H | N | N | H | H | N | N |

- T – heat-bonded geotextile, I – needle-punched geotextile

Geotextiles of other technical parameters may be ordered according to the Customer’s requirements.
11.3. Sequence of tasks to be performed when installing a rainwater storage system

1. Dig a trench at least 40 – 50 cm wider than the width of the box module.

2. Remove any protruding stones from the trench bed and lay down min. 10 – 15 cm of sand bedding (no stones). Even out and compact the sand.

3. Remove the open-work covers from the connection points of the 160 mm supply pipes, 110 – 220 mm ventilation pipes and 200 mm inspection pipes.

4. At the bottom lay out the geotextile (grammage at least 300 g/m²), leaving an overlap of at least 15 cm – 30 cm, then lay out the geomembrane (hydro-insulating foil), at least 1.5 mm thick. The foil (dimensions 2 m x 20 m) is laid out with an overlap of approx. 10 cm and welded.

5. Lay out the ground plates and boxes on the geotextile and connect them together, using clips. The points where clips should be placed are marked with the word “CLIP”.

6. Carefully wrap the geotextile around the boxes, leaving an overlap of 15 cm – 50 cm. At the inlets prepare openings by making cuts in the geotextile.

7. Wrap the boxes with foil and weld it. Make openings at the inlets of supply, ventilation and inspection pipes into the boxes. Next, prepare pipes of a total length of 50 cm (excluding the socket). Onto each of the prepared pipe ends place a butyl gasket and then a foil sleeve, which should be welded to the pipe. Insert approx. 20 cm of the pipe into the box opening, and then weld the foil sleeves around the pipes. Place a metal rim around the foil sleeve and tighten the pipe joint. The rim may be additionally secured by wrapping with foil and welding.
10. Cover the boxes with a 10–15 cm layer of sand without stones or other sharp-edged elements. Even out and compact the ground. Pay particular attention to securing the trench sides as to prevent stones and other sharp elements from mixing with the sidefill surrounding the box. It is recommended to additionally press the lid by covering it with geotextile.

11. Before the construction of the tank, bearing capacity of the soil should be tested. In case of low bearing capacity, soil settlement should be prevented by complete removal of the bed and replacement with concrete footing or compacted gravel and sand footing (1:0.3) at least 15 cm deep. Construction stability in areas of low bearing capacity may also be increased by load resistance calculations.

Geotextile and geomembrane parameters should be chosen based on the box arrangement and expected loads. Before the construction of the tank, bearing capacity of the soil should be tested. In case of low bearing capacity, soil settlement should be prevented by complete removal of the bed and replacement with concrete footing or compacted gravel and sand (1:0.3) or at least 15 cm deep. Construction stability in areas of low bearing capacity may also be increased by load resistance calculations.

Guidelines for sealing the lid by gluing the flexible foil edge to the lid are as follows. Lay the lid on a hard surface, overlapping them by at least 5 cm. The sealed edges must be dry, clean and degreased. Using a flat brush apply glue to both edges and immediately press them together.

Technical parameters of geotextiles used in the construction of underground retention tanks

<table>
<thead>
<tr>
<th>Property</th>
<th>TCM 300</th>
<th>TCM 350</th>
<th>TCM 400</th>
<th>HTS 300</th>
<th>HTS 350</th>
<th>HTS 400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>geowłóknina **</td>
<td>folia nieprzepuszczalna PVC*</td>
<td>geowłóknina **</td>
<td>geowłóknina **</td>
<td>folia nieprzepuszczalna PVC*</td>
<td>geowłóknina **</td>
</tr>
<tr>
<td>Water permeability (GSD)</td>
<td>22</td>
<td>18</td>
<td>28</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Temperature resistance (°C)</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>Dynamic puncture resistance (kN)</td>
<td>1.3</td>
<td>1.2</td>
<td>1.1</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Static puncture resistance</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Wear resistance (CM)</td>
<td>11.6</td>
<td>11.6</td>
<td>11.6</td>
<td>11.6</td>
<td>11.6</td>
<td>11.6</td>
</tr>
<tr>
<td>Reaction to fire - PN-EN 13501-1 Class E</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Compatibility with asphalt - PN-EN 1548</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Resistance to root penetration- PR-CEN/TS 14416 no perforation</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Water permeability (GSD)  | 11.6 | 11.6 | 11.6 |
| Temperature resistance (°C) | -2  | -2  | -2  |
| Dynamic puncture resistance (kN) | 1.3 | 1.2 | 1.1 |
| Static puncture resistance | 22  | 22  | 22  |
| Wear resistance (CM)       | 11.6 | 11.6 | 11.6 |
| Reaction to fire - PN-EN 13501-1 Class E | - | - | - |
| Compatibility with asphalt - PN-EN 1548 | - | - | - |
| Resistance to root penetration- PR-CEN/TS 14416 no perforation | 0 | 0 | 0 |

For special and PVC foil thicknesses please contact a TCM 300 HTS 300. Flexible sheets for waterproofing. Plastic and rubber damp-proof sheets including plastic and rubber basement tanking sheet. Definitions and characteristics.”

Technical parameters of PVC foil used in the construction of underground retention tanks

<table>
<thead>
<tr>
<th>Property</th>
<th>Test</th>
<th>Test method</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness mm</td>
<td>1.5</td>
<td>ISO 11058</td>
<td>1.5 ± 10%</td>
</tr>
<tr>
<td>Dimensions (L x W) m</td>
<td>2 x 20</td>
<td>ISO 1848-2</td>
<td>2 x 20 ± 5%</td>
</tr>
<tr>
<td>Physical strength (kN/m)</td>
<td>14</td>
<td>ISO 10319</td>
<td>14</td>
</tr>
<tr>
<td>Tensile strength (kN/m²)</td>
<td>21</td>
<td>ISO 11058</td>
<td>21</td>
</tr>
<tr>
<td>Tear resistance (kN/m²)</td>
<td>20</td>
<td>ISO 11058</td>
<td>20</td>
</tr>
<tr>
<td>Flame spread index</td>
<td>12</td>
<td>ISO 5660-1</td>
<td>12</td>
</tr>
<tr>
<td>Reaction to fire (class)</td>
<td>E</td>
<td>ISO 13501-1</td>
<td>E</td>
</tr>
</tbody>
</table>

** Geotextile, grammage min. 300 g/m². If ungraded sand (with stones) is used as packing material, additional protective geotextile should be used around the foil.

* Water-proof PVC foil, e.g. 1.5 mm thick FolGAM H type.

Diagram showing the method of sealing a pipe to lower the water lever to beneath the bottom of the tank. You should also ask Pipelife to perform load resistance calculations.
11.4. Connecting pipes to boxes

In order to connect the plain ends of PVC-U, PP-B dn 110, 160 mm pipes to the side walls, cut out the polypropylene reinforcements from the inlet openings. After wrapping geotextile around the boxes and cutting out a hole matching the diameter of the pipe, insert a PVC-U, PP-B pipe approx. 20 cm long. Carefully secure the connection so as to prevent the soil from entering the box module.

The illustration above shows a box with prepared 160 mm holes.

When building wide tanks with a large, flat surface, plan water supply connections in several places, to distribute water evenly. You can make holes in the other side walls and in the top boxes in a similar manner.

At the top of every box there are 2 openings d n 110, 160 or 200 mm, which can be used to insert cleaning equipment or CCTV all the way to the bottom of the box module (provided that the open-work covers have been removed from the holes of every layer of boxes).

Diagrams showing the connection of a d n 160 mm PVC-U inlet pipe to the side of the box

160 mm inspection openings at the top of Stormbox

Every Stormbox has holes located along the horizontal and vertical axis. It allows access into the boxes as far as the other end of the box module, both through the side walls and through the top.

The top inspection opening may be used for the duct connector of a d n 160, 200 mm PVC-U sewage pipe with a socket. Vertical sewage pipes running to the level of the ground should be installed at the points at which inspections will be carried out.

The pipes should be covered to protect them from inadvertent water entry. The polypropylene reinforcements should be cut out from all the holes located on the sides and at the top, through which inspections are to be carried out.

11.5. Connecting boxes to settling chambers

The boxes may be connected to inspection chambers PRO 400, PRO 630 and manholes PRO 800 and PRO 1000 with a settling tank and a filter at the outlet. Depending on the flow rates, the flow rate should be distributed between an appropriate number of 160 mm supply pipes connected to the side, or 200 mm pipes connected to the top of the boxes. 200–500 mm diameter pipes can be connected to the boxes using a Stormbox adaptor.

When connecting a large diameter (e.g. 315 mm) pipe to a PRO 800 or PRO 1000 manhole, make 4 holes at the outlet in the body of the chamber for the 160 mm gaskets and 160 mm filters, or 1 hole for a 341/315 mm gasket and a 315 mm filter.

Diagram showing the connection of a box module to a PRO 800, PRO 1000 chamber

Settling chambers PRO 400 and PRO 630 may be fitted with a settling bucket, located underneath the inlet to the chamber, where leaves and other debris will collect. This solution is particularly useful if there are leaves near the building.

For draining yards or car parks there are inspection chambers with a telescope and branes, T30K (12.5 t) or T50K (25 t), and a settling bucket, made of PE or galvanised steel.

The settling bucket with a steel frame should be placed inside the telescope. The settling buckets are supported by special gaskets which fit both the short (h=25 cm) and the long (h=40 cm) model.

<table>
<thead>
<tr>
<th>Inlet diameter [mm]</th>
<th>Outlet diameter [mm]</th>
<th>Min. number of pipes at the outlet [pcs.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>160</td>
<td>2 PRO 630</td>
</tr>
<tr>
<td>250</td>
<td>160</td>
<td>3 PRO 800</td>
</tr>
<tr>
<td>315</td>
<td>160</td>
<td>4 PRO 1000</td>
</tr>
<tr>
<td>400</td>
<td>160</td>
<td>6 PRO 1000</td>
</tr>
</tbody>
</table>

The final number of pipes at the outlet can be calculated based on the flow rate (dm³/s) and pipe gradient (%).
PRO 1000 or PRO 800 settling chamber

**Filter properties:**
- Made from stainless steel.
- Large filtration surface.
- Conical shape for easier self-cleaning.
- Filter diameters 160 ÷ 400 mm for larger flows (larger drainage areas).
- Filter diameter 110 mm for small flows (small drainage areas).
- Can be used with 90° triple connectors to external sewage systems.
- Can be used in plastic and concrete chambers.
- The number of filters at the outlet (up to 4) can be adjusted to the diameter of the chamber inlet (up to 400 mm).
- Quick installation of the chamber and filter at the site.

The top part of the filter should be inserted into the socket of the triple connector, and the steel catches should be fixed with a clamping ring. To preserve the minimum safe distance of 50 mm from the concrete ring, trim the top part of the 630 mm reducer outlet by 26 mm (to 35 mm).

### Diagram showing an example of a PRO 1000, PRO 800 settling chamber connected with a 160 mm pipe

1. PRO 800, PRO 1000 chamber with settling tank and filter
2. 160 mm PVC-U sewage pipe
3. Stormbox
4. Telescopic TD 40 (4) or 55SM (5)
5. 160 mm PVC-U sewer pipe
6. Telescopic class A15 + D 400
7. PRO 400 chamber
8. Ventilation pipe with air valve cover 110 or 160 mm

### Diagram showing an example of a PRO 1000, PRO 800 settling chamber with a Stormbox adapter

1. PRO 800, PRO 1000 settling chamber with steel filter

### Table: Selecting the hole diameter in the outflow regulator

<table>
<thead>
<tr>
<th>Hole Diameter</th>
<th>Water Outflow (l/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 mm</td>
<td>1</td>
</tr>
<tr>
<td>36 mm</td>
<td>2</td>
</tr>
<tr>
<td>44 mm</td>
<td>3</td>
</tr>
<tr>
<td>51 mm</td>
<td>4</td>
</tr>
<tr>
<td>57 mm</td>
<td>5</td>
</tr>
<tr>
<td>62 mm</td>
<td>6</td>
</tr>
<tr>
<td>67 mm</td>
<td>7</td>
</tr>
<tr>
<td>72 mm</td>
<td>8</td>
</tr>
<tr>
<td>76 mm</td>
<td>9</td>
</tr>
<tr>
<td>80 mm</td>
<td>10</td>
</tr>
</tbody>
</table>

Water outflow depends on the height of the water level in the chamber.
13.6. Inspections and cleaning of the boxes

Stormbox has three internal horizontal inspection channels to introduce CCTV (digital) cleaning equipment. The boxes have ventilation areas by IBAK ROCH RETEKP (the Netherlands), BASF SE BPE (Poland), and 403388 OFI Technologie & Innovation GmbH (Austria), confirming that it is possible to perform CCTV inspection and hydrodynamic cleaning up to 180 bar. The boxes were subjected to water pressure of 180 bar through standard JIS 50 bar (25 cycles). The test results showed no damage to the box structure that could adversely affect their functioning. The test therefore confirms the high quality of the boxes and their high resistance to hydrodynamic pressures.

Stormbox may be inspected vertically and horizontally.

Box with a vertical channel enables maintenance and the introduction of cleaning equipment from the ground all the way to the bottom through 200 mm chambers installed above the boxes or 400, 630, 800 and 1000 mm chambers installed next to the tank. Two vertical openings 200 mm in diameter provide access from the ground all the way to the bottom of the tank for purposes of inspection and cleaning. There are two openings 160 mm in diameter in the side walls and two openings 200 mm in diameter at the top of the box. Supply pipes 200–500 mm in diameter can be connected to the side of Stormbox using an adaptor. Stormbox has three horizontal inspection channels 160 mm in diameter and two vertical channels 200 mm in diameter. Please note, however, that according to standard PN-EN 13476-1, maximum nozzle pressure should not exceed 120 bar.

Research and general practices in Europe have shown that a 120 bar pressure is sufficient for all plastics. It removes any blockages which may occur during normal operation, and impurities are directed to chambers with large amounts of water. The results of independent rinsing studies have shown that a large amount of water at a low pressure is more effective as a means of removing obstacles and completely cleaning out sediment buildup from pipes, as well as for routine maintenance. Such methods use large diameter nozzles (typically 2.8 mm).

Recommended practical parameters for high pressure cleaning:

For soft debris and impurities, 60 bar is sufficient.

Rinsing pressure/flow speed:

1. Recommended nozzle pressure: up to 60 bar.
2. Recommended debris rinsing speed: 6 m/min – 12 m/min.

Rinsing equipment:

1. Choose rinsing equipment using low pressure and large amounts of water.
2. Avoid methods requiring high pressure and small amounts of water.
3. Choose nozzle size based on the equipment used and the size of the pipe to be cleaned.

Diagram showing an example method of inspecting the Stormbox module

Diagram showing an example of a Stormbox system with a settling chamber PRO 400 mm or PRO 630 mm with a cascade at the inlet and a 200 mm or 400 mm inspection chamber

1. settling chamber 400 mm or 630 mm with cascade
2. PVC-U sewage pipe 160 mm
3. Stormbox
4. 200 mm inspection chamber with telescope T05M (5 t) or T20 (40 t)
5. Ventilation pipe with air valve cover 110 mm or 160 mm

Diagram showing an example of a Stormbox system with a settling chamber 400 mm or 630 mm with a cascade at the inlet and a 200 mm or 400 mm inspection chamber

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11.7. Minimum distances from the building or other objects

- 2.0 m from a building with insulation.
- 5.0 m from a building without insulation.
- The distance between the infiltration boxes and the building should be at least 1.5 of the building's foundation depth.
- 3.0 m from trees.
- 2.0 m from a building with insulation, and 3.0 m from trees.
- The distance between the infiltration boxes and the building should be at least 1.5 of the building's foundation depth.
- 1.0 m from groundwater level.

11.8. Digging trenches

The trench should be filled with permeable materials, such as gravel, working in layers and compacting the ground to the required level, as per documentation.

11.9. Preparing the trench bed

The trench bed must be even, without large stones, large lumps of soil or debris. It must be made sure that effectiveness of permeability dig trenches is to a greater depth, and then even out the bottom by spreading out appropriate graded material. Coarse sand or rockfill is the most cost efficient solution since it requires the least compaction to achieve the correct density.

Permeable graded material (sand, rockfill) is placed in the trench using appropriate equipment, and then manually rammed and tamped to ensure that the ground is suitable, well compacted and steady to provide good support for the box module.

A suitable bed may also achieved using soil dug out from the trench and appropriately prepared, provided the soil does not contain large stones (more than 40 mm in diameter), hard lumps or debris, and can be compacted to the right density.

Materials used for the sidefill and backfill must be free from caked silt and aggradate containing large rock fragments and soils with high organic content, providing the soil does not contain large stones, large lumps of soil or debris and can be compacted to the right density.

11.10. Soil classification

Category I includes gravel and coarse rockfill with grain sizes: 4-16, 8-12, 2-22 mm. A minimum of 5-30 mm of 2 mm grains is allowed. This is the best bedding material.

Category II includes gravel and stone mixture of sand and gravel with varying small percentage of fine sand, gravel and clay. This category also includes various mixtures of gravel and clay, or gravel and sand with varying small particle content.

Category III includes gravel and stone mixture of fine sand, clayey sand or gravel and clay. This category also includes various mixtures of fine sand, clayey sand or gravel and clay. A maximum of 5-20% of 2 mm grains is allowed. It is good bedding material.

11.11. Sidefill compaction

Ground compaction in the tank area and the selection of side fill suitable for compaction should comply with PN-ENV 1046.

- The degree of compaction, with relation to the specific degree of difficulty of the pressure, depends on the load conditions:
  - Annular, car parks (road traffic)
  - the required degree of sidefill compaction is 5%.
  - without road traffic:
  - the required degree of sidefill compaction is 15% SPC.
- The trench bed should be compacted to 95% SPC.
- i.e. due to requirements regarding the surface structure.
- The recommended density for sidefill should be from SPC 1 to SPC 3.

In the absence of detailed information regarding natural soil, it is usually assumed that its cohesion is zero, and it is soft compact stiff hard.

Granular soil loose moderately compacted compacted heavily compacted

Expected degree of consolidation in compaction

Expected degree

Table 3 shows the maximum layer thickness and the number of compaction passes for various types of compaction equipment and bedding material. It also shows the maximum thickness of the cover layer above the pipe before using appropriate compacting equipment above the boxes.

11.12. Drainage system

- The drain should be located in the lowest point of the tank area.
- Infiltration systems should not be installed in soil belonging to category IV and V. Such soils should also not be used for sidefill.

Recommended layer thickness and number of compaction passes

<table>
<thead>
<tr>
<th>Compaction index</th>
<th>Compaction class</th>
<th>Low (L)</th>
<th>Medium (M)</th>
<th>High (H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Backfill material group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category I</td>
<td>Gravel and coarse rockfill</td>
<td>600 kg</td>
<td>400 kg</td>
<td>200 kg</td>
</tr>
<tr>
<td>Category II</td>
<td>Gravel and sand mixture</td>
<td>15 kg</td>
<td>10 kg</td>
<td>10 kg</td>
</tr>
<tr>
<td>Category III</td>
<td>Fine sand, clay, gravel, materials</td>
<td>50 kg</td>
<td>30 kg</td>
<td>20 kg</td>
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</table>

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<td>10 kg</td>
</tr>
<tr>
<td>Category III</td>
<td>Fine sand, clay, gravel, materials</td>
<td>50 kg</td>
<td>30 kg</td>
<td>20 kg</td>
</tr>
</tbody>
</table>

Recommended layer thickness and number of compaction passes

<table>
<thead>
<tr>
<th>Compaction index</th>
<th>Compaction class</th>
<th>Low (L)</th>
<th>Medium (M)</th>
<th>High (H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Backfill material group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category I</td>
<td>Gravel and coarse rockfill</td>
<td>600 kg</td>
<td>400 kg</td>
<td>200 kg</td>
</tr>
<tr>
<td>Category II</td>
<td>Gravel and sand mixture</td>
<td>15 kg</td>
<td>10 kg</td>
<td>10 kg</td>
</tr>
<tr>
<td>Category III</td>
<td>Fine sand, clay, gravel, materials</td>
<td>50 kg</td>
<td>30 kg</td>
<td>20 kg</td>
</tr>
</tbody>
</table>

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</tr>
<tr>
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<td>50 kg</td>
<td>30 kg</td>
<td>20 kg</td>
</tr>
</tbody>
</table>
12.1. Hydraulic conductivity

It is a property of rock and soil that describes the ease with which water in laminar flow can move through porous substances. The percolation occurs through a network of channels made up of soil pores. The soil resists the percolating water; the degree of resistance and the hydraulic conductivity depend on the soil properties:

- type of soil medium
- porosity
- granulation
- soil structure
- properties of the percolating liquid – viscosity.

Determining hydraulic conductivity

1. Empirical formula method
   - Requires data on the granulometric composition of the soil. The granulometric chart and the porosity value. This method gives approximate results.

2. Constant hydraulic gradient measurement
   - The test involves percolating water through a sample of known geometric dimensions and measuring the flow rate and the hydraulic gradient. Hydraulic conductivity is determined using Darcy’s equation:
     \[ k = \frac{Q}{F \times I} \]

3. Field method (percolation test)
   - The test involves measuring the amount of time needed for the water level to drop in a presoaked hole 15 cm in diameter and 30 cm in height.

Conclusions:

- Stormbox units may be installed under a cover layer of at least 0.8 m for HGV traffic load of SLW 40, SLW 60 assuming ground compaction of at least 95% and appropriate surface structure (at least 40 cm).

12.2. Determining the infiltration suitability of soil

The infiltration suitability of soil should be determined based on geotechnical tests of the soil, establishing the hydraulic conductivity of the soil and the groundwater level. Soil permeability may be initially assessed by means of a percolation test according to local or American methodology (ASTM).

1. Percolation test – Polish method
   - At the appropriate depth, at the level of the ground plates, make a hole 30 cm x 30 cm in cross-section and 15 cm deep. Presoak the soil with water.
   - In case of sandy soils several buckets will suffice. On soils with low permeability, the presoaking may take several hours. Pour 12.5 dm³ of water into the hole and measure the percolation rate, expressed in minutes. Based on the percolation time it is possible to assess the soil category and its suitability for infiltration.

<table>
<thead>
<tr>
<th>Hp</th>
<th>Hs</th>
<th>Hd</th>
<th>Sidefill type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.82</td>
<td>3.62</td>
<td>G1 95</td>
<td>SLW 60 (60 t)</td>
</tr>
<tr>
<td>Asphalt h1 = 0.2 m, Ep = 13,000 MPa, rockfill with cement h2 = 0.2 m, Ep = 10000 MPa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.82</td>
<td>3.62</td>
<td>G1 95</td>
<td>SLW 40 (40 t)</td>
</tr>
<tr>
<td>Asphalt h1 = 0.2 m, Ep = 13,000 MPa, rockfill with cement h2 = 0.2 m, Ep = 10000 MPa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.82</td>
<td>3.62</td>
<td>G1 95</td>
<td>SLW 30 (30 t)</td>
</tr>
<tr>
<td>Asphalt h1 = 0.2 m, Ep = 13,000 MPa, rockfill with cement h2 = 0.2 m, Ep = 10000 MPa</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Soil classification and properties

<table>
<thead>
<tr>
<th>Soil parameter</th>
<th>Sandy gravel, gravel, coarse sand</th>
<th>Medium and fine sand, clayey sand</th>
<th>Sandy clays</th>
<th>Clay or silt with a small amount of sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>hp</td>
<td>&lt; 20</td>
<td>20 - 30</td>
<td>&gt; 180</td>
<td></td>
</tr>
<tr>
<td>hs</td>
<td>&lt; 1.4</td>
<td>1.4 - 2.1</td>
<td>&gt; 12.8</td>
<td></td>
</tr>
<tr>
<td>Soil category</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td></td>
</tr>
</tbody>
</table>

12. Design guidelines

12.1. Hydraulic conductivity

It is a property of rock and soil that describes the ease with which water in laminar flow can move through porous substances. The permeation occurs through a network of channels made up of soil pores. The soil resists the percolating water; the degree of resistance and the hydraulic conductivity depend on the soil properties:

- type of soil medium
- porosity
- granulation
- soil structure
- properties of the percolating liquid – viscosity.
12.3. Hydraulic conductivity

2. Hydraulic conductivity

3. Percolation test – EPA (American) method

The amount of precipitation should be based on actual precipitation in the given region (data from the Institute of Meteorology and Water Management). The retention and infiltration system must have appropriate storage capacity to hold the water until it infiltrates into the ground.

12.4. Guidelines on rainwater infiltration

Infiltration systems are usually designed without drainage. It is possible, however, for the infiltration system to be equipped with an emergency overflow, through a settling chamber to another receptacle of rainwater, or an emergency overflow, through a settling separator.

When calculating tank dimensions, it is necessary to calculate tank capacity to hold the first wave of runoff from the drainage area (data from the Institute of Meteorology and Water Management). Infiltration systems are usually designed without drainage. It is possible, however, for the infiltration system to be equipped with an emergency overflow, through a settling chamber to another receptacle of rainwater, or an emergency overflow, through a settling separator.

Water percolation rate [min./25 mm], soil type, permeability [min./cm], filtration rate [cm/h].

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Permeability [min./cm]</th>
<th>Filtration rate [cm/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good: rockfill, gravel, coarse sand, loam</td>
<td>&gt; 120</td>
<td>&gt; 15</td>
</tr>
<tr>
<td>Good: non-uniform and medium sand</td>
<td>50 – 120</td>
<td>10 – 15</td>
</tr>
<tr>
<td>Medium: fine sand, loess</td>
<td>20 – 50</td>
<td>5 – 10</td>
</tr>
<tr>
<td>Poor: silty and clayey sand, loam, sandstone</td>
<td>5 – 20</td>
<td>1 – 2</td>
</tr>
<tr>
<td>Impermeable rock: silt, claystone, compact mudstone, sandy silt</td>
<td>&lt; 5</td>
<td>&lt; 1</td>
</tr>
</tbody>
</table>

12.5. Dimensioning guidelines

For hydraulic calculations, Pipelife used precipitation data from local weather institutes and weather stations. The absorption system should be chosen based on the accepted rainfall intensity for a given region. The retention and infiltration system must have appropriate storage capacity to hold the water until it infiltrates into the ground.

When dimensioning the system, make calculations for the given exceedance probability from p=2÷10 years for all rainfall intensities from 15 minutes to 360 minutes. Then find the critical rainfall intensity and duration for which the retention capacity will be largest. You should limit your calculations, e.g. to just one rainfall duration of 15 minutes and one rainfall intensity of 136, dm³/h, or only when local authorities require this.

According to ATV A 117 and ATV A 138, the minimum capacity of a retention tank must be chosen based on rainfall intensity and duration, so as to ensure reliability of the system in case of an overload.

The following data is needed to calculate tank dimensions:

- type and area of the drained surface [m²]
- type of soil and its hydraulic conductivity [m/s]
- initial size of the trench, installation depth etc.
12.7. Probability of precipitation

According to ATV A-118 the following rainfall frequencies are accepted:

- p = 10% for rural settlements – 1 in 10 year event
- p = 15% for urban settlements – 1 in 2 year event (taking into account flooding)
- p = 20% for objects in town centres and towns (including and service centres) – 1 in 5 year event (not taking into account flooding)
- p = 25% for particularly important objects, e.g. underground facilities, low-level parts of commercial centres – 1 in 5 year event
- p = 50% for urban settlements – 1 in 2 year event
- p = 70% for commercial centres – 1 in 10 year event
- p = 90% for particularly important objects, e.g. underground facilities, low-level parts of manufacturing and service centres – 1 in 10 year event

The system must not be overloaded by the chosen design rainfall. In urban settlements the flooding frequency is once every 20 years (1 in 20 year event), in town centres once every 30 years (1 in 30 year event), and for underground facilities it is once every 50 years (1 in 50 year event).

Methods of preventing the overload of retention tanks (in case of selection for short rainfall duration):

- water flowing out to the surface, with appropriate modulation.
- water elevation in the system over a short period of time
- water flowing out into a ditch or basin and directed to a receptacle.
- connection to a receptacle through an overflow chamber with backwater protection.

When designing underground miniature infiltration and storage systems, emergency overflow should be planned. The overflow protects the system from an overload caused by rainfall heavier than the value assumed for calculation purposes, with an appropriate exceedance probability.

The level of reliability should be increased in industrial areas which are subject to additional contamination hazards. Such is the case where there is a risk of contamination related to the leakage of petroleum derivatives or chemicals. Such surfaces should be isolated using special technical devices, e.g. control chambers, hydrocarbon separators and light fluid treatment devices, e.g. control chambers.

Such surfaces may be isolated between devices to cut off the flow if necessary. Tanks to collect the excess of contaminated water should be planned as needed.

12.8. Calculating the amount of runoff from a given catchment area

Methods of preventing the overload of retention tanks (in case of selection for short rainfall duration):

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12.12. Calculating the amount of outflow in a given time

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Such surfaces may be isolated between devices to cut off the flow if necessary. Tanks to collect the excess of contaminated water should be planned as needed.
12.13. Calculating the required size of a rainwater infiltration system

Tank dimensions may be calculated e.g. using the following formula according to DWA-A 138:

\[ V = \frac{(A \cdot \psi) \cdot 10^{-7} \cdot rD(n) \cdot D \cdot 60 \cdot fz}{(b \cdot h \cdot sr + (b + 0.75) \cdot D \cdot 60 \cdot fz \cdot h)^2} \]  

\( V \) — tank volume [m³]
\( A \) — surface area [m²]
\( \psi \) — runoff coefficient
\( rD(n) \) — rainfall intensity [dm³/s · ha]
\( D \) — rainfall duration [min.]
\( fz \) — safety factor, \( f_z = 1.2 \)
\( b \) — width of infiltration boxes [m]
\( h \) — height of infiltration boxes [m]
\( sr \) — net water capacity factor (for Stormbox \( sr = 0.955 \))
\( kf \) — hydraulic conductivity of the soil [m/s]

The calculations have been performed for a rainwater coefficient of \( \psi = 1 \). For rainwater from roofs, roads etc. the volume given in the table should be multiplied by the given runoff area and amount of precipitation by the appropriate rainwater coefficient value.

Pipelife calculates the tank retention capacity according to ISSO 70-1 and DWA-A 117.

### Stormbox system selection program

The program assists in choosing the optimum number of boxes for the planned maximum tank dimensions (L x W x H).

Pipelife can also perform calculations related to the selection of retention tanks or retention and infiltration tanks with a constant outflow through a flow regulator.

Tank capacities calculated using the first wave of runoff holding method – P = 50% (2 years)

<table>
<thead>
<tr>
<th>Duration of rainfall ( t ) [min]</th>
<th>Amount of precipitation ( P ) [mm]</th>
<th>Tank capacity and number of boxes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Drainage area ( \psi = 1 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volume ([m^3])</td>
</tr>
<tr>
<td>15</td>
<td>100</td>
<td>1.5</td>
</tr>
<tr>
<td>30</td>
<td>200</td>
<td>2.4</td>
</tr>
<tr>
<td>60</td>
<td>300</td>
<td>4.4</td>
</tr>
<tr>
<td>120</td>
<td>400</td>
<td>8.8</td>
</tr>
<tr>
<td>180</td>
<td>500</td>
<td>15.2</td>
</tr>
<tr>
<td>240</td>
<td>600</td>
<td>25.2</td>
</tr>
<tr>
<td>300</td>
<td>700</td>
<td>37.9</td>
</tr>
<tr>
<td>360</td>
<td>800</td>
<td>54.6</td>
</tr>
<tr>
<td>420</td>
<td>900</td>
<td>75.3</td>
</tr>
<tr>
<td>480</td>
<td>1000</td>
<td>99.8</td>
</tr>
</tbody>
</table>

Tank capacities calculated using the first wave of runoff holding method – P = 20% (5 years)

<table>
<thead>
<tr>
<th>Duration of rainfall ( t ) [min]</th>
<th>Amount of precipitation ( P ) [mm]</th>
<th>Tank capacity and number of boxes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Drainage area ( \psi = 1 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volume ([m^3])</td>
</tr>
<tr>
<td>15</td>
<td>100</td>
<td>1.9</td>
</tr>
<tr>
<td>30</td>
<td>200</td>
<td>2.6</td>
</tr>
<tr>
<td>60</td>
<td>300</td>
<td>5.4</td>
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<tr>
<td>120</td>
<td>400</td>
<td>10.8</td>
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<tr>
<td>180</td>
<td>500</td>
<td>19.4</td>
</tr>
<tr>
<td>240</td>
<td>600</td>
<td>34.5</td>
</tr>
<tr>
<td>300</td>
<td>700</td>
<td>54.5</td>
</tr>
<tr>
<td>360</td>
<td>800</td>
<td>79.5</td>
</tr>
</tbody>
</table>

### Calculation of the efficiency of infiltration system

\[ V = \frac{(A \cdot \psi) \cdot 10^{-7} \cdot rD(n) \cdot D \cdot 60 \cdot fz}{(b \cdot h \cdot sr + (b + 0.75) \cdot D \cdot 60 \cdot fz \cdot h)^2} \]  

\( V \) — tank volume [m³]
\( A \) — surface area [m²]
\( \psi \) — runoff coefficient
\( rD(n) \) — rainfall intensity [dm³/s · ha]
\( D \) — rainfall duration [min.]
\( fz \) — safety factor, \( f_z = 1.2 \)
\( b \) — width of infiltration boxes [m]
\( h \) — height of infiltration boxes [m]
\( sr \) — net water capacity factor (for Stormbox \( sr = 0.955 \))
\( kf \) — hydraulic conductivity of the soil [m/s]

The calculations have been performed for a runoff coefficient of \( \psi = 1 \). For rainwater from roofs, roads etc. the volume given in the table should be multiplied by the given surface area and amount of precipitation by the given rainwater coefficient value.

Pipelife calculates the tank retention capacity according to ISSO 70-1 and DWA-A 117.

Tank dimensions can also be calculated using the formula given in ISSO 70-1.

Pipelife calculates the required number of boxes for the planned maximum tank dimensions (L x W x H).

The large surface areas of side wall openings (approx. 50% of the total surface) ensure very favourable conditions for the infiltration of rainwater. It is possible to check the operation of the system with reduced infiltration through the bottom (in case of poor maintenance of the bottom of the system).
Boxes are a more modern and more efficient water infiltration solution than e.g. concrete soakways or collector pipes. The net capacity of an infiltration box is 206 dm³; that is 3 times more than a drainage ditch filled with rockfill. One box can replace approx. 1,200 kg of rockfill (approx. 0.69 m³) with the storage factor of 30%. To achieve the same capacity as a box, a rockfill trench would have to be 3 times longer, with the dimensions 0.6 m x 0.3 m x 3.8 m. An infiltration box can replace approx. 32 m of a 100 mm PVC-U collector pipe.

**Example calculations of the required number and volume of boxes**

The following calculations assume rainfall duration of 15 min to several hours, with rainfall probability of 1 in 2 years.

**North-west region of Poland**

**Soil type** | Average soil permeability coefficient \( k \) | Volume and number of boxes | North-west region of Poland
---|---|---|---
Coarse sand | \( 10^{-3} \) | Roofs drainage area [m²], \( \psi = 0.95 \)
100 | 86.4 | 0.41 | 2
150 | 86.4 | 0.62 | 3
200 | 86.4 | 0.82 | 4
250 | 86.4 | 1.03 | 5
300 | 86.4 | 1.24 | 6
Medium sand | \( 5 \times 10^{-4} \) | 0.62 | 3
100 | 43.2 | 1.03 | 5
150 | 43.2 | 1.24 | 6
200 | 43.2 | 1.65 | 8
250 | 43.2 | 2.06 | 10
Fine sand | \( 5 \times 10^{-5} \) | 1.65 | 8
100 | 4.32 | 2.47 | 12
150 | 4.32 | 3.09 | 15
200 | 4.32 | 4.12 | 20
250 | 4.32 | 4.94 | 24
Silty or clayey sand | \( 5 \times 10^{-6} \) | 2.88 | 14
100 | 0.432 | 4.12 | 20
150 | 0.432 | 5.77 | 28
200 | 0.432 | 7.21 | 35
250 | 0.432 | 8.65 | 42
Clay | < \( 10^{-8} \) | Infiltration not possible | 0
100 | < \( 8.6 \times 10^{-4} \) | | 0
150 | < \( 8.6 \times 10^{-4} \) | | 0
200 | < \( 8.6 \times 10^{-4} \) | | 0
250 | < \( 8.6 \times 10^{-4} \) | | 0

The calculation of number of boxes is approximate. To obtain accurate calculations, please contact Pipelife Customer Service Department.
13. Operation of the infiltration system

An infiltration system should undergo periodic inspections. Settling chambers must be checked for the amount of debris collected. It is recommended that the chambers should be inspected every six months and the collected debris periodically removed.

Stormbox infiltration boxes have 6 inspection openings 110, 160 mm in diameter and 2 openings 110, 160 and 200 mm in diameter to enable the insertion of cleaning equipment and CCTV.

Underground infiltration systems require periodic inspections – at least once a year. Such inspections should be carried out before periods of frost.

Underground systems should be for example:
- Protected from leaves and other debris,
- Kept at a suitable distance from trees (to protect the boxes from damage by developing root systems),
- Infiltration boxes should be rinsed,
- Mechanical pre-treatment devices should undergo maintenance. Again, every 6 months check the amount of debris in the settling tank and remove as necessary.

13.2. Operation in winter

Underground miniTec infiltration systems are generally resistant to reduced infiltration in winter. Minimum cover layers above the boxes should be preserved, according to the ground freezing depth in the area. Additionally boxes are covered with a layer of LECA at least 20 cm in depth.

The risk of flooding in freezing temperatures is slight, or torrential rate very easily falls on frozen ground. The maximum rate of snow melting is 2 mm/h, much less than the runoff of a standard design rainfall.

The following requirements should be met when installing Stormbox infiltration systems:
- PN-EN 1610:2002 Construction and inspection of sewage systems;
- PN-ENV 1046:2007 Plastic pipeline systems – Outdoor water and sewage systems – Overground and underground installation practices;
- PN-EN 1295-1:2002 Static calculations for ground-buried pipelines at various load conditions. Part 1: General requirements;
- PN-EN 1295-3:1999 Ground work. Open excavations for water and sewage systems. Technical conditions of work;
- ATV-A 116 "Hydraulic Dimensioning and Verification of Drainage Systems"
- DWA-A 136 "Planning, Bus and Betrieb von Anlagen zur Verhinderung von Niederschlagswasser".
- DNI 1993-3 “Rainwater harvesting systems – Part 1: Planning, installation, operation and maintenance”
- DNI 1993-3 “Rainwater harvesting systems – Part 3: Collecting tanks for rainwater”
- ISSO 70-1 “Omgaan met hemelwater binnen de perceelgrenzen”
- BRL 52250 “Kunsttstof infiltratiesystemen voor hemelwater”
- "Planung, Bau und Betrieb von Anlagen zur Verhinderung von Niederschlagswasser".
- "Bemessung von Regenrückhalteräumen. Regulation of the Minister of Transport and Marine Economy of 2 March, 1999 on the technical conditions to be fulfilled by public roads and their location (Poland)"