3

TECHNICAL MANUAL

WASTE SYSTEMS

Configurations of waste systems

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CONFIGURATIONS OF WASTE SYSTEMS

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CONFIGURATIONS OF WASTE SYSTEMS

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3.1 Wastewater drainage

Wastewater produced in buildings (homes, offices, hospitals, schools, hotels, etc.) can be divided into:

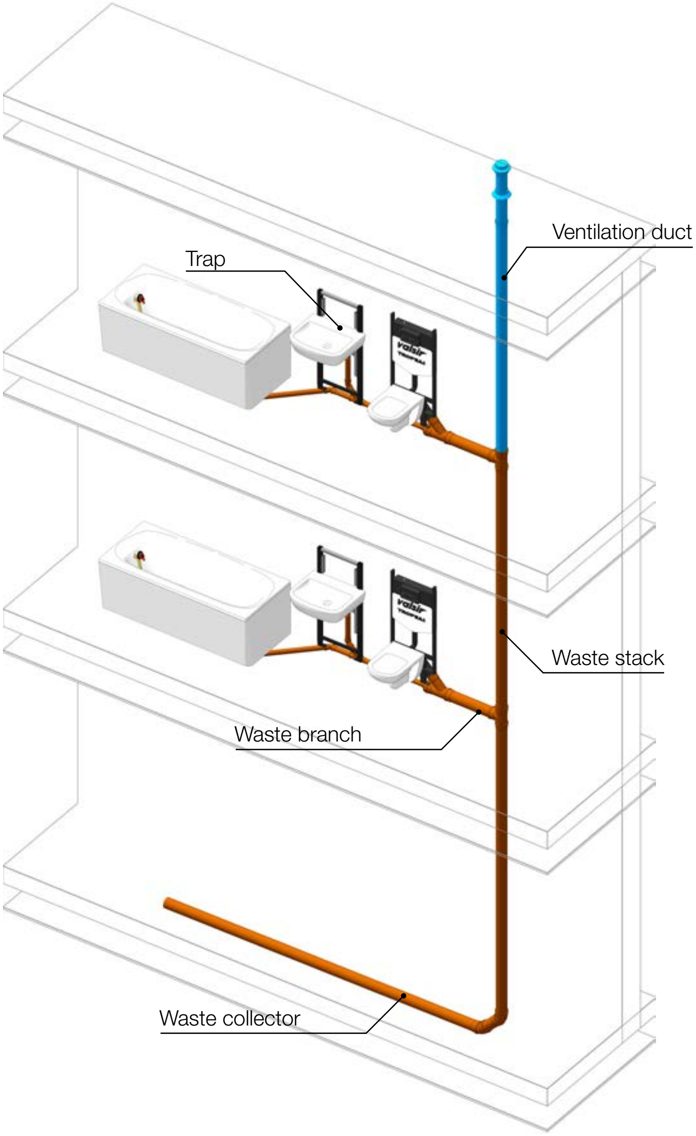
- **Black water**: wastewater containing faecal matter or urine.
- **Grey water**: wastewater not containing faecal matter or urine.
- **White water**: coming from rain (meteoric water) or watering of gardens, vegetable gardens and parks.

In waste systems, the 3 types described above can be kept completely independent or, as so often happens where local regulations allow this, black water is combined with grey water in a single waste system. This is because black and grey water have approximately the same characteristics and peculiarities.
White water is always drained independently to avoid the risk of system saturation in case of heavy rainfall which would cause a significant increase in drain flows.

The waste system is made up of:

- **Traps** fitted directly on the sanitary fixtures in case of sinks, bidets and kitchen sinks, placed on the floor in case of bathtubs and showers, incorporated in the fixture in the case of toilet bowls and urinals in order to prevent malodorous air from spreading in the rooms.
- **Waste branches** made up principally of horizontal pipes that connect siphons to waste stacks.
- **Waste stacks** made up principally of vertical pipes that connect waste branches to waste collectors.
- **Waste collectors** consisting of pipes with slight slopes, that collect water coming from waste stacks and convey it to the sewage system. Waste collectors can be installed underground or suspended on the ceiling of basements or garages.
- **Ventilation ducts** consisting of mainly vertical pipes connected to the waste piping system, that limit pressure variations, allow air circulation and ensure a silent drainage of sanitary fixtures.

Figure 3.1 Structure of a waste system in a residential building.



The waste system must ensure:

- A rapid discharge of the flow, the absence of deposits and sediments, the water seal and the seal against gas in order to protect hygiene standards in the rooms and the health of the users.
- The design pressure levels when in function thus allowing the re-integration of the air that is drawn and pushed out during the discharge.

3.2 Traps

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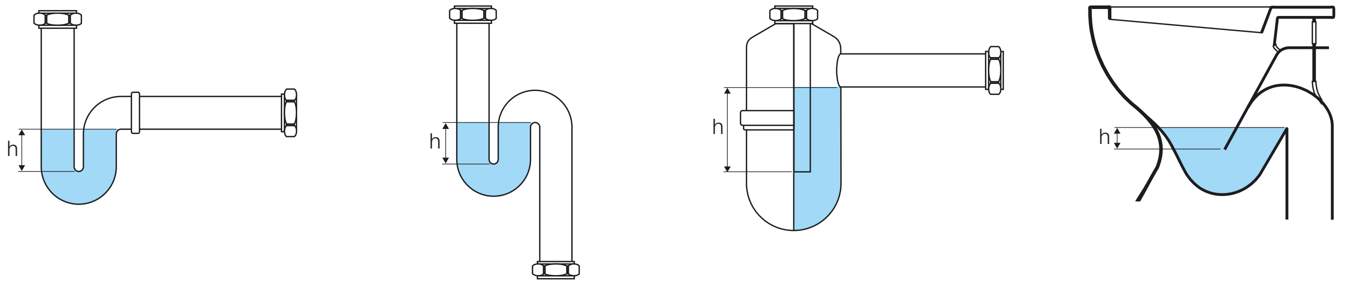
The trap is the component that ensures the water seal preventing the escape of foul smelling gases into the room. The water seal is obtained by means of trapping a certain quantity of water that acts as a “water plug” characterised by a certain height defined as “water guard”. When the sanitary fixture is flushed, the weight of the liquid generates sufficient pressure on the inlet side of the trap to push the stagnant water toward the outlet side of the trap and therefore into the waste branch and, thereafter, into waste stack. When the flush is over, the pressure equilibrium between the two sides of the trap is re-established and a new “water plug” is created ensuring the water seal of the system.

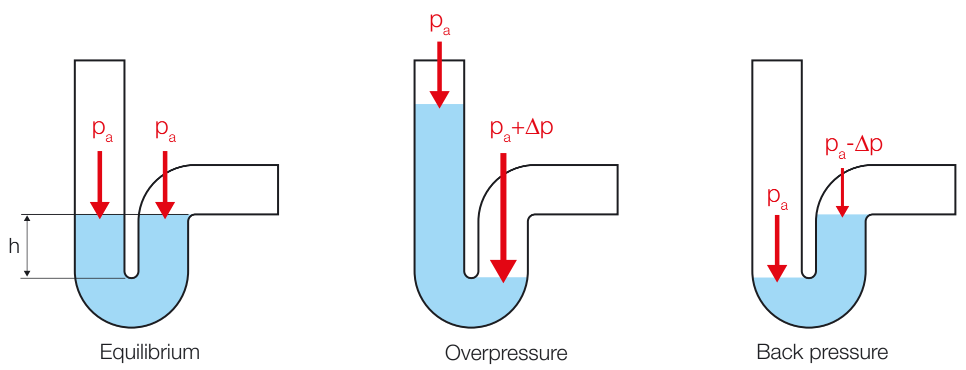
The water guard of the trap, in accordance with the European Standard UNI EN 12056, should be no less than 50 mm in order to ensure the efficiency of the “water plug” even when the waste system is in use and pressures and vacuums are generated inside the system network. Another important consideration is linked to the fact that the presence of the “water plug” must be guaranteed also when the sanitary fixture is not in use and when climatic conditions lead to a gradual water evaporation (especially during summer months). With an average evaporation of the water of approximately 1.5 mm a day, the water seal can be guaranteed for about 30 days.

Figure 3.2 Water guard in the traps.



When a sanitary fixture flushes a large amount of water into the waste system, compression and back pressure occur, affecting the “water plug” in the trap.
These phenomena are caused by the pressure variations Δp that can either be positive (overpressure) of negative (back pressure): positive pressures $p_a + \Delta p$ act on the water contained in the trap and push it from the exit side toward the inlet side, whereas negative pressures $p_a - \Delta p$ suck water from the inlet side toward the outlet side of the trap. The “water plug” is set in motion by these pressure changes, which causes it to change its configuration from hydrostatic equilibrium. If the waste system is not properly dimensioned, pressure variations can cause the “water plug” to move until it is completely removed, allowing foul-smelling gas to escape.

Figure 3.3 Movements of the “water plug” in the trap.



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3.2.1 Siphonage

Consider the system layout indicated in Figure 3.4. When the sanitary fixture B is flushed, it generates a "water plug" in the stack that moves downward, creating a pressure greater than the atmospheric pressure. Such a difference could be such as to push the water in the trap into the fixture C causing the emission of foul-smelling gas into the room; this phenomenon is called **siphonage caused by compression**.
Simultaneously the "water plug" generates back pressure in the fixture A, which, if significant, sucks the water from the trap, removing the water seal and causing the emission of a foul-smelling gas into the room; this phenomenon is called **siphonage caused by aspiration**.

Of course these phenomena can be more or less serious and are in general influenced by factors such as:

- Insufficient water guard in the trap.
- Insufficient diameter of the waste stack.
- Missing or insufficient ventilation system.
- Incorrect configuration of the foot of the stack.

Figure 3.4 Effects of siphonage.

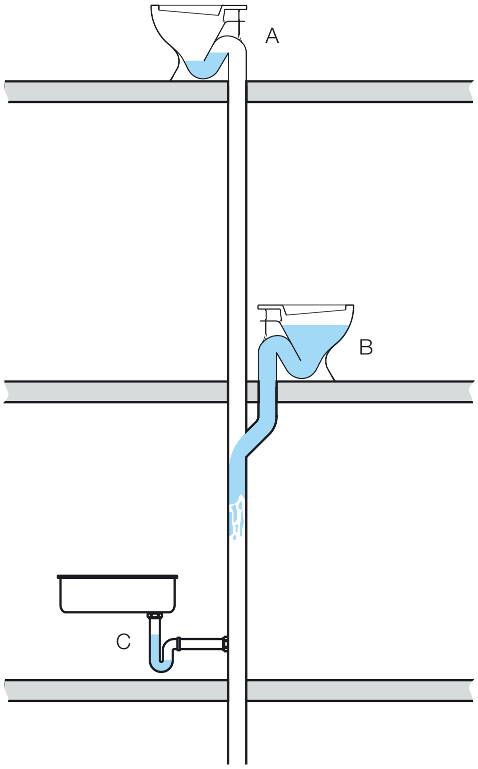
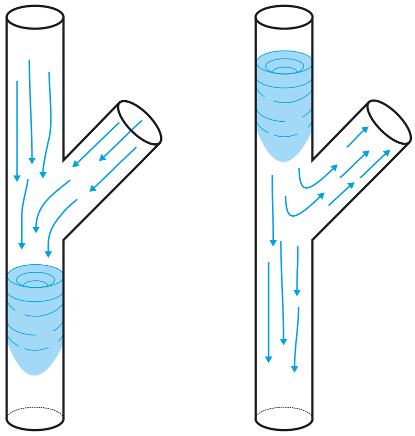


Figure 3.5 Siphonage caused by aspiration (point A) and compression (point C).



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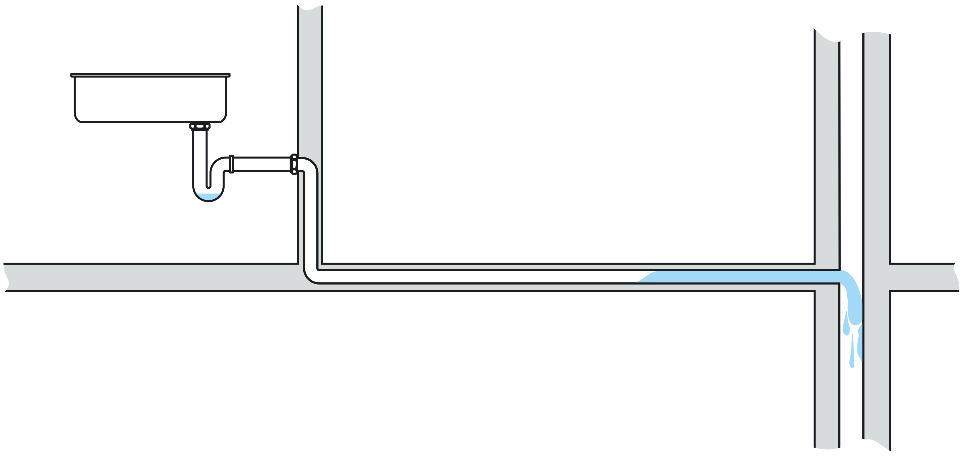
3.2.2 Self-siphonage

Self-siphonage occurs in horizontal waste branches when they are too long or when the trap is too narrow. In this case the phenomenon is not caused by the “water plug” generated by one of the fixtures but by the flushing of the fixture itself. Self-siphonage may lead to the removal of the trap seal causing the emission of foul-smelling gas into the room in question. To explain this phenomenon we can see what happens when attempting to transfer liquid (petrol, oil, wine, etc.) from one container to another with the use of a small diameter tube.
Once all of the liquid has been transferred, no trace of it is left inside the tube and that is exactly what happens inside a waste branch and the trap of the sanitary fixture. Restrictions on the length of waste branches are defined in the European Standard UNI EN 12056-2 and are indicated in the chapter on system sizing. Self-siphonage occurs when the trap of the fixture being flushed makes a noise that is similar to human “snoring”. When such a noise comes from the trap of a non-operating fixture, the cause is aspiration siphonage; compression siphonage, on the other hand, is distinguished by a gurgling sound produced within the trap when one of the fixtures in the system is being used.

Figure 3.6 Self-siphonage of a sanitary fixture.



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3.3 Ventilation

The maintenance of the pressure levels inside the waste system network and the elimination of the siphonage effects are guaranteed by suitable ventilation systems of the conduits. Ventilation systems are made up of pipes that are connected to the waste system to ensure a flow of air that limits pressure variations and ensures the silent operation of the sanitary fixtures. When wastewater flows down the drainage system, the pipe's passage cross section partially or completely obstructs the flow. Using an analogy, the flow behaves like the plunger of a syringe, therefore it compresses the air downstream creating overpressure and draws the air upstream creating a vacuum effect. We can correct these imbalances thanks to the ventilation system. The European Standard UNI EN 12056 defines different configurations of ventilation systems both for the waste stacks and the waste branches. In practice, there are numerous alternatives to the basic configurations defined by the Standard that provide numerous variations suitable for resolving system requirements.

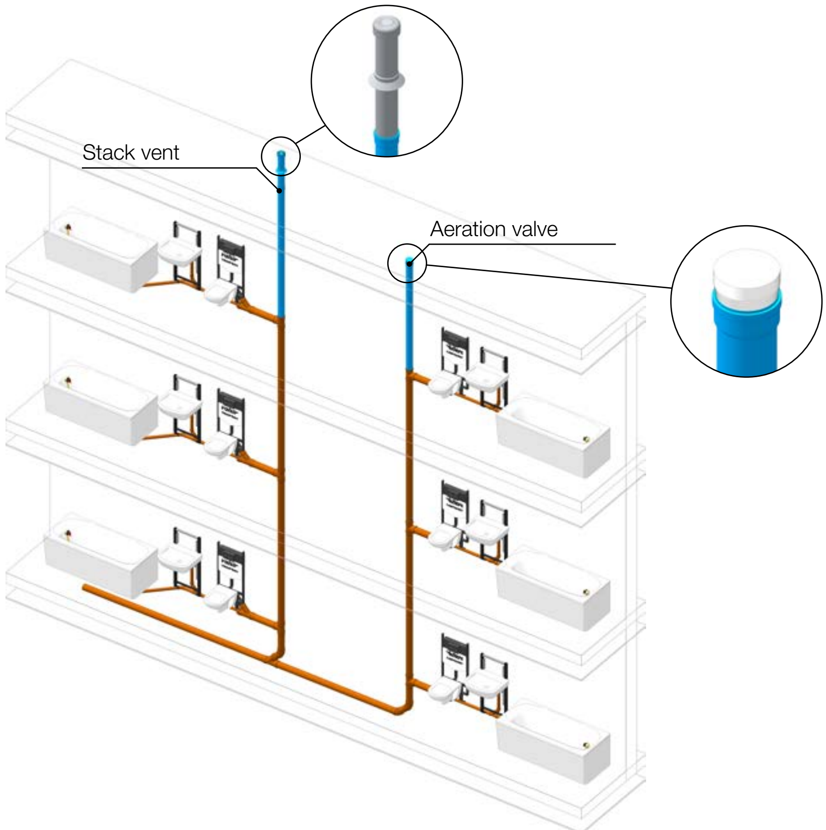
3.3.1 Waste systems with primary ventilation

This is the most economical and widely used system. Ventilation is guaranteed by the extension of the waste stack to the roof; this end piece of pipe-work is defined as the waste stack relief vent. As an alternative to the roof extension, it is possible to use aeration valves that ensure the inflow of air into the stack while preventing the discharge of foul-smelling gases into the room.

Primary ventilation systems have the following characteristics:

- It is the most simple and economic system.
- The primary ventilation system eliminates the effect of aspiration siphonage but not compression siphonage. While the back pressure above the fixture is compensated for by the inlet of air through the stack vent, the increase in pressure at the foot of the stack cannot be compensated. Therefore, other particular configurations in the waste collector are necessary depending on the number of floors in the building.
- The European Standard UNI EN 12056 requires that the stack vent to be no smaller in diameter than the waste stack.
- Waste branches must be no longer than 4 m and must have a minimum slope of 1% (for more details refer to the chapter on waste system sizing).

Figure 3.7 Waste system with primary vent.



3.3.1.1 Primary ventilation system for up to 2 storeys buildings (h ≤ 4 m)

For buildings with a maximum of 2 storeys in which the distance between the highest and lowest discharge point is h ≤ 4 m, the fixtures can be connected directly to the stacks even if the waste collector hangs from the ceiling of the underground floor. The functioning of this type of configuration is guaranteed by the fact that the pressure that is generated at the foot of the stack is of such an entity as to have no effect on the sanitary fixtures connected on the ground floor.

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Figure 3.8 Primary ventilation, 2-storey building (h ≤ 4 m), collector in the pavement of the underground floor.

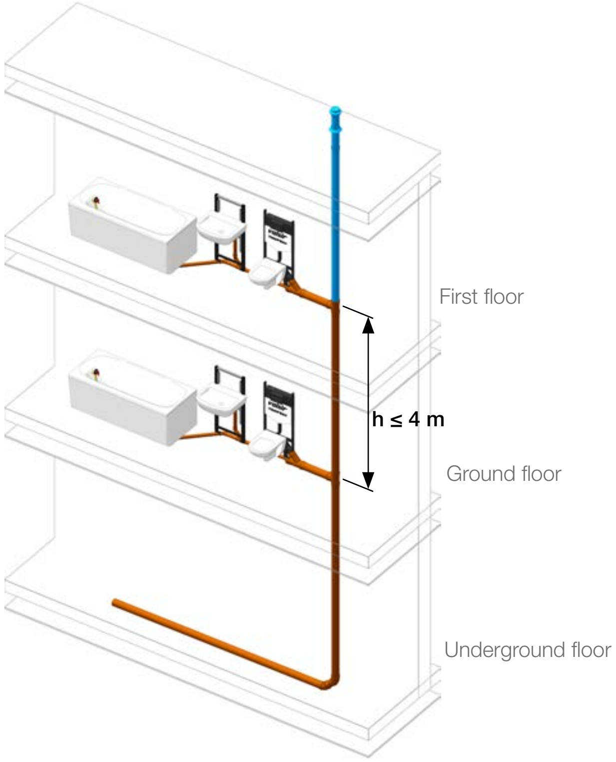
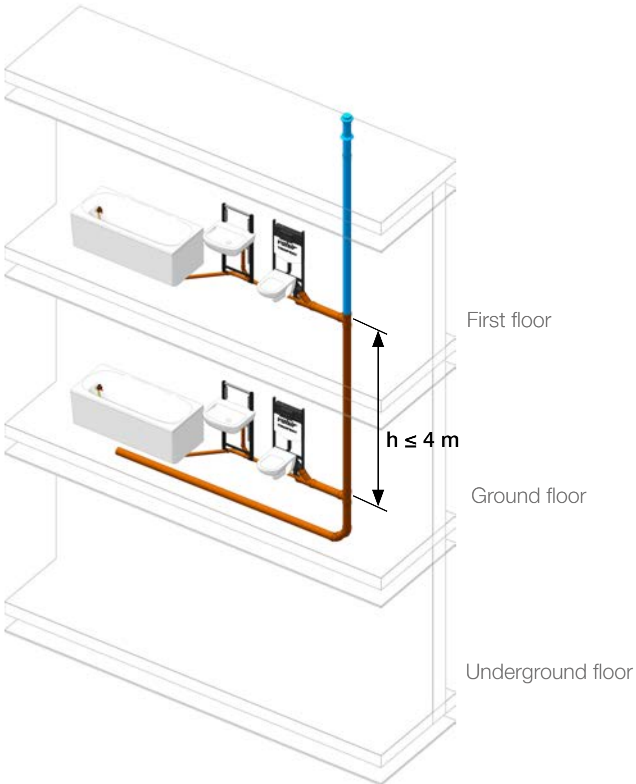


Figure 3.9 Primary ventilation, 2-storey building (h ≤ 4 m), collector on the ceiling of the underground floor.



3.3.1.2 Primary ventilation systems for 3 to 5 storey buildings (h ≤ 12 m)

For buildings from 3 to 5 floors for which the distance between the highest and lowest drainage point is h ≤ 12 m, the pressure generated within the system becomes even at a height of approx. 3 m from the stack foot.

To avoid that the pressure has a negative effect on the nearest fixtures to the stack foot, it is necessary to connect them to the waste network in a different manner depending on the position of the collector.

- If the collector is in the pavement of the underground floor, the fixtures on the ground floor can be connected directly to the stack because the pressure does not interfere with their functioning.
- If the collector is connected to the ceiling of the underground floor the fixtures on the ground floor must be connected to the waste collector at over 1 m from the stack foot since, in this case, the pressure that is generated would interfere with their functioning.

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Figure 3.10 Primary ventilation, 3÷5 storey building (h ≤ 12 m), collector in the pavement of the underground floor.

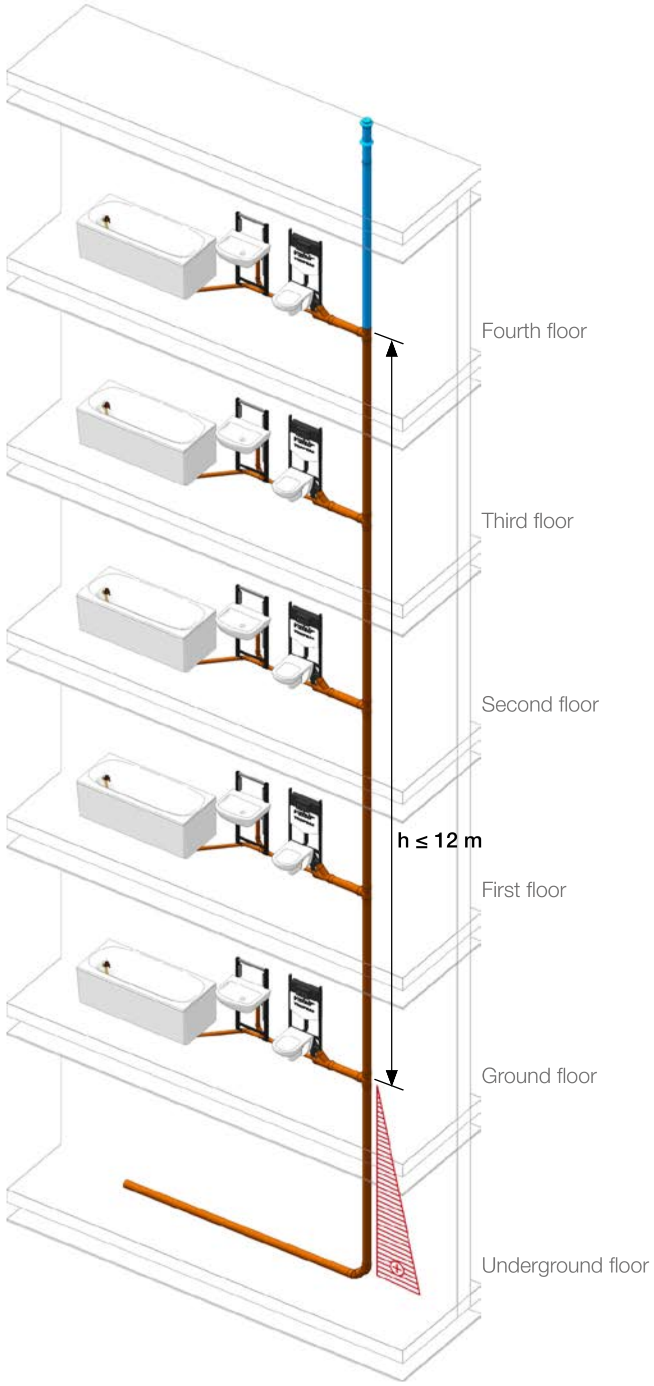
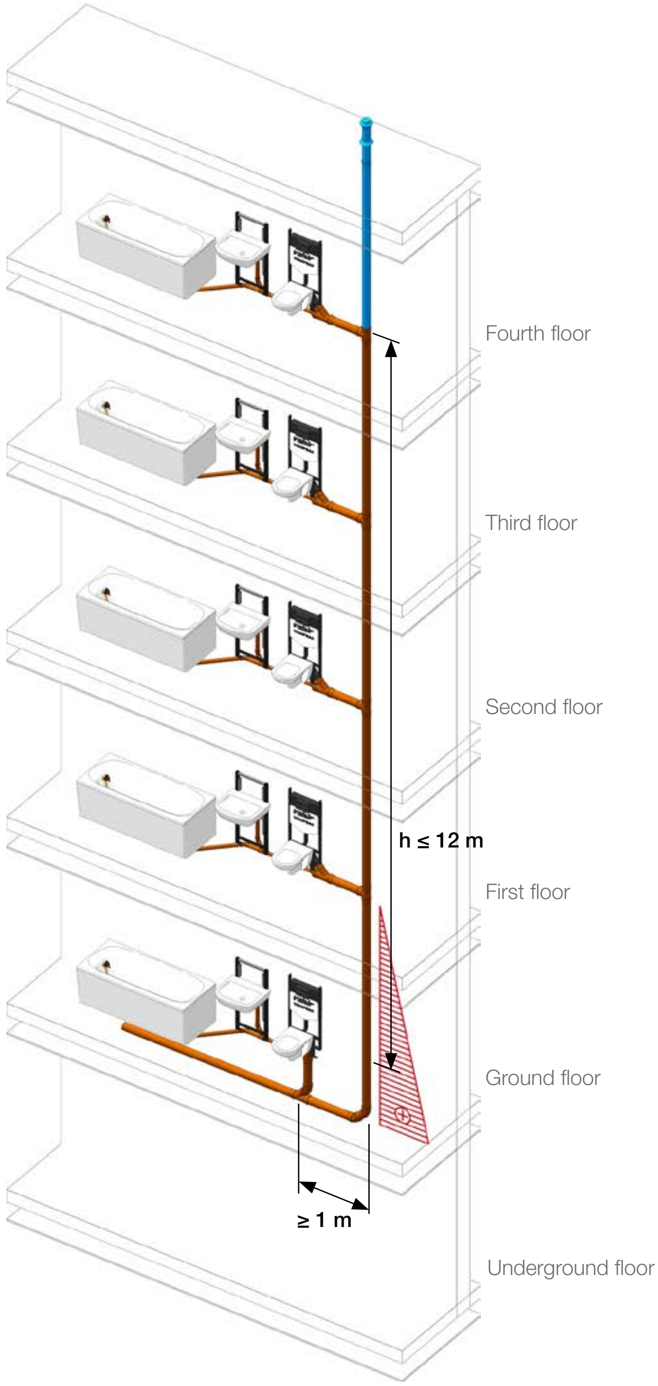


Figure 3.11 Primary ventilation, 3÷5 storey building (h ≤ 12 m), collector on the ceiling of the underground floor.



3.3.1.3 Primary ventilation system for buildings with over 5 storeys (h > 12 m)

For buildings with over 5 storeys in which the distance between the highest and the lowest fixture is h > 12 m a pressure is generated that is then cancelled above 3 m in height from the base of the stack. To avoid that pressure adversely affects the fixtures closest to the stack foot, it is necessary to connect them to the waste collector by splitting the stack at a distance greater than or equal to 2 m.

To aid the ventilation of the second waste stack it is necessary to connect it to the main stack by means of a piece of pipe-work called "loop vent". The loop vent guarantees the flow of air required to limit the pressure differentials inside the second waste stack when one of the fixtures is used.

In any case Valsir recommends a parallel ventilation system in buildings made up of over 5-6 floors.

Figure 3.12 Primary ventilation, building with over 5 storeys (h > 12 m), collector in the pavement of the underground floor.

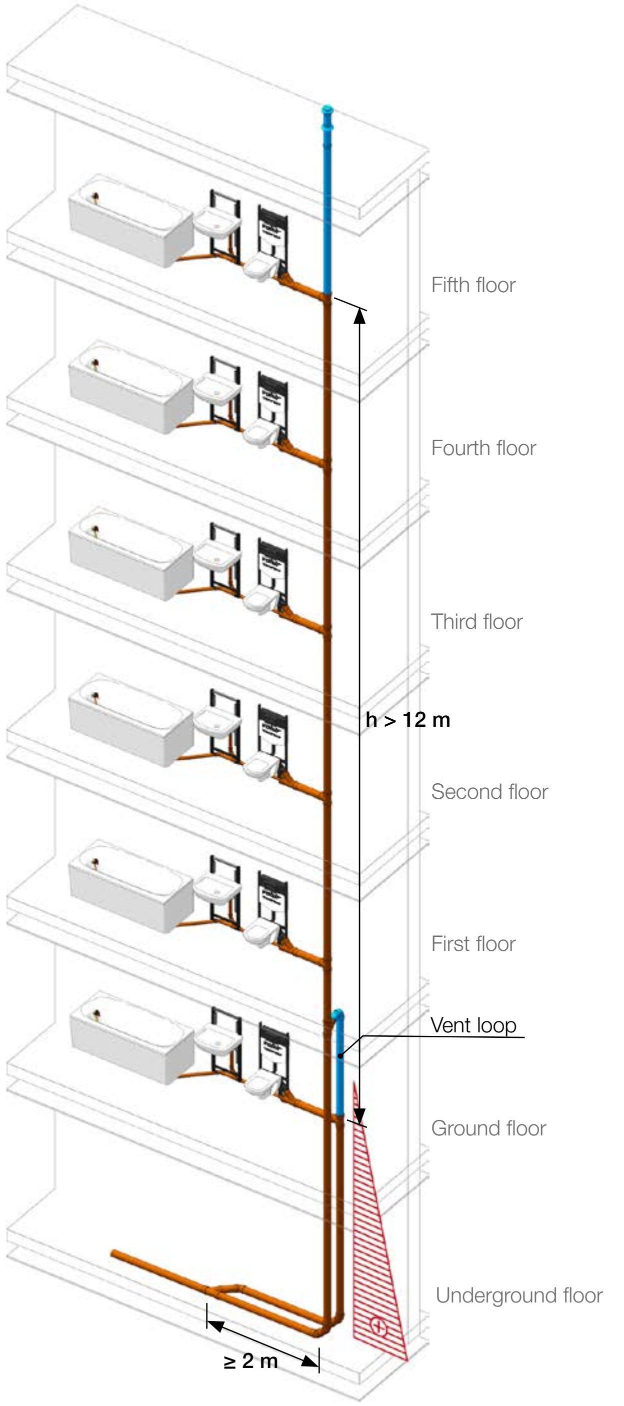
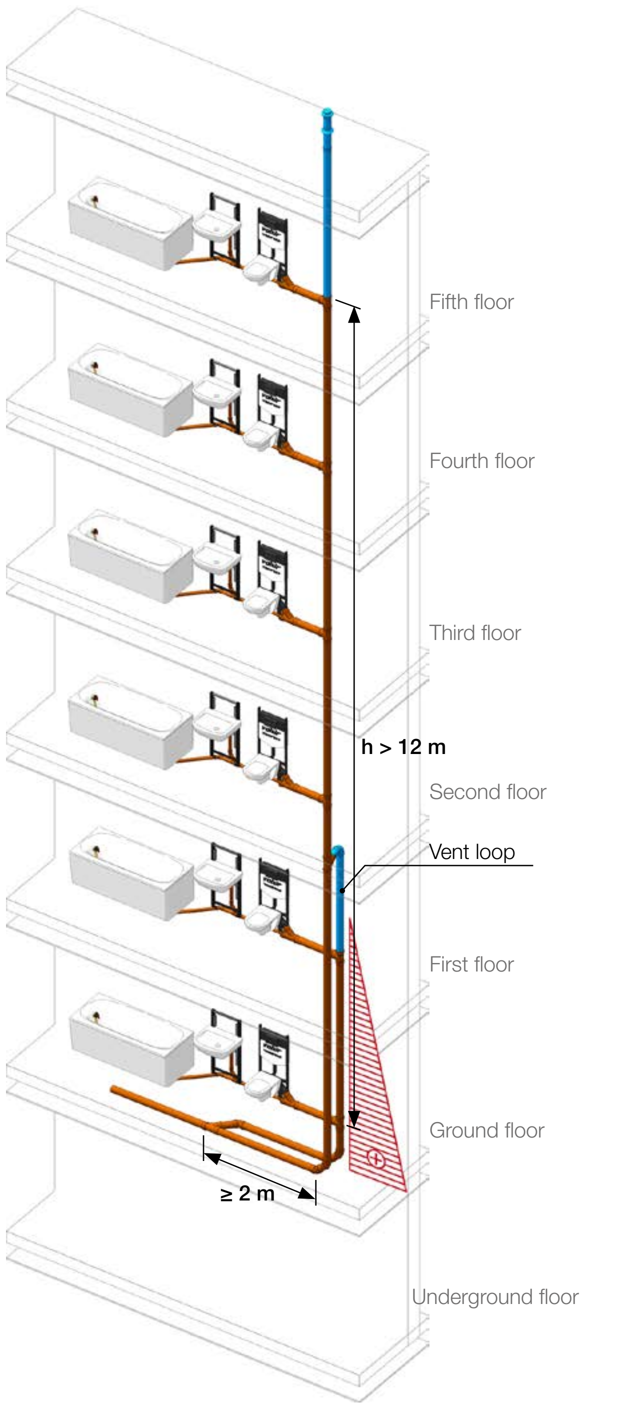


Figure 3.13 Primary ventilation, building over 5 storeys high (h > 12 m), collector in the ceiling of the underground floor.



3.3.2 Waste system with direct and indirect parallel ventilation

This is a system made up of a vent stack that runs parallel to the waste stack. In systems with a direct parallel vent, the vent stack is connected to the waste stack, whereas systems with an indirect parallel vent, the vent stack is connected to the waste branches. Again, in this case, the waste stack is extended to the roof (relief vent) or it ends in the room with an aeration valve. Depending on the number of floors that need to be served, the vent stack may have intermediate connections with the waste stack that ensure a sufficient circulation of air within the network.

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Characteristics of parallel ventilation systems:

- Not as economical as primary ventilation systems.
- Suitable for buildings with more than 2 storeys.
- It eliminates both the intake and the compression effect on siphons, as the ventilation stack allows air to recirculate from the stack foot to the relief vent.
- Compared to a primary vent system with the same diameter, a parallel vent systems increases the waste flow rates by 30÷40% (see the chapter on waste system sizing).
- The European Standard UNI EN 12056 sets a minimum diameter for the parallel vent stack in relation to the diameter of the waste stack (see the chapter on waste system sizing).
- If the parallel vent is direct, the waste branches must have a maximum length of 4 m and a gradient of at least 1%; if it is indirect, the branches can be as long as 10 m with minimum gradients of 0.5% (for more details, refer to the chapter on waste system sizing).

Figure 3.14 Waste system with parallel vent (direct and indirect).

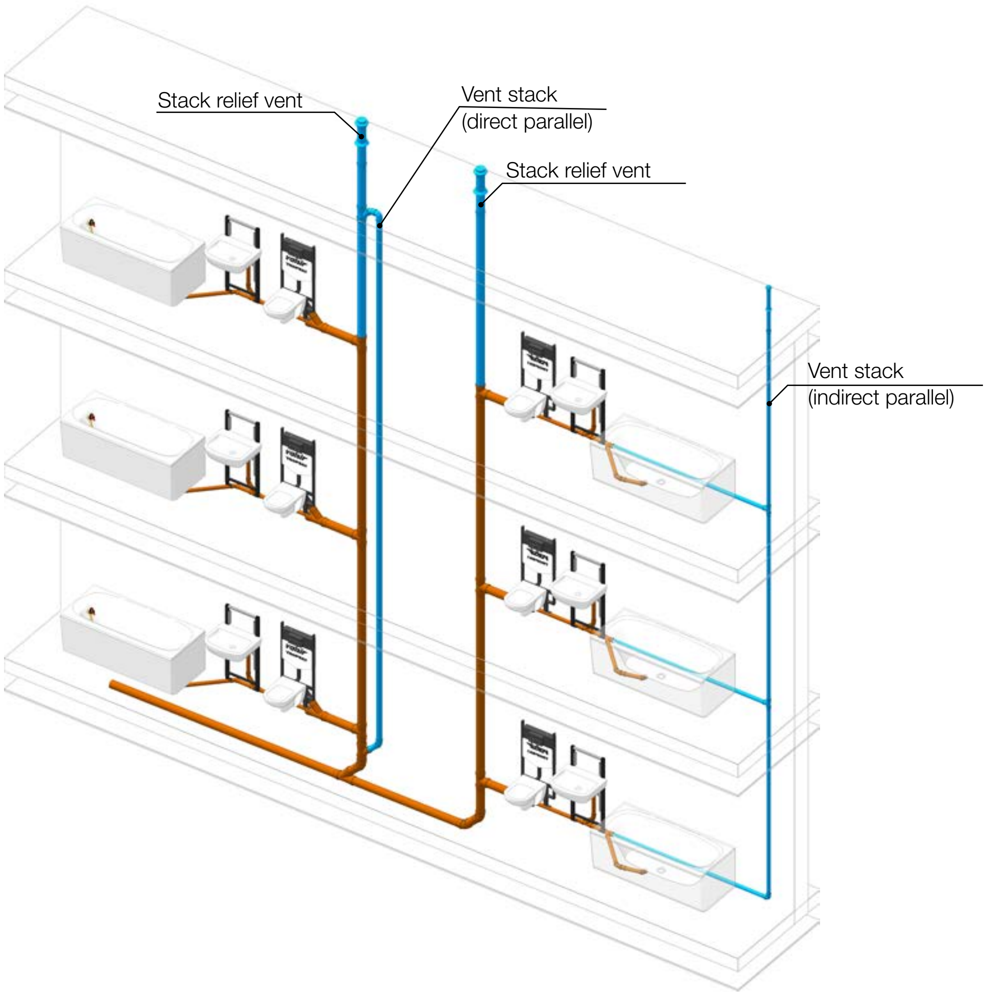
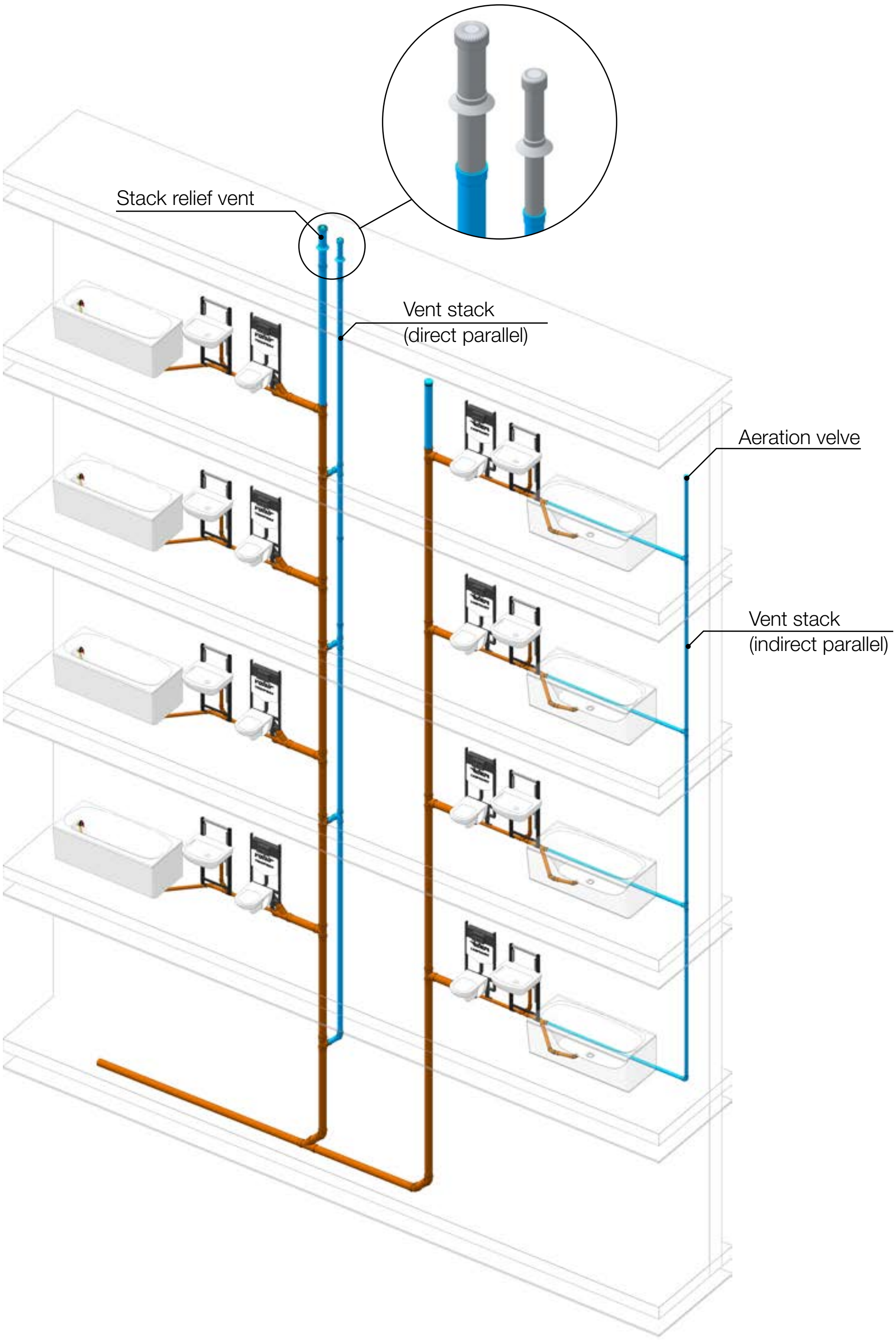


Figure 3.15 Waste system with parallel vent (direct and indirect) with variations.



3.3.2.1 Direct parallel vent system for buildings with 3 to 5 storeys (h ≤ 12 m)

For buildings from 3 to 5 floors, the parallel ventilation stack is connected at the bottom near the stack foot and at the top to the vent cowl.
To avoid the possibility of foam rising, the ground floor must be connected in a different manner depending on the position of the collector.

- If the collector is in the pavement of the underground floor, the ground floor fixtures can be connected directly to the stack.
- If the collector is attached to the ceiling of the underground floor, the ground floor fixtures must be connected to the waste collector at over 1 m in height from the stack foot to avoid the possibility of foam rising.

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Figure 3.16 Direct parallel vent, 3÷5 storey building (h ≤ 12 m), collector in the pavement of the underground floor.

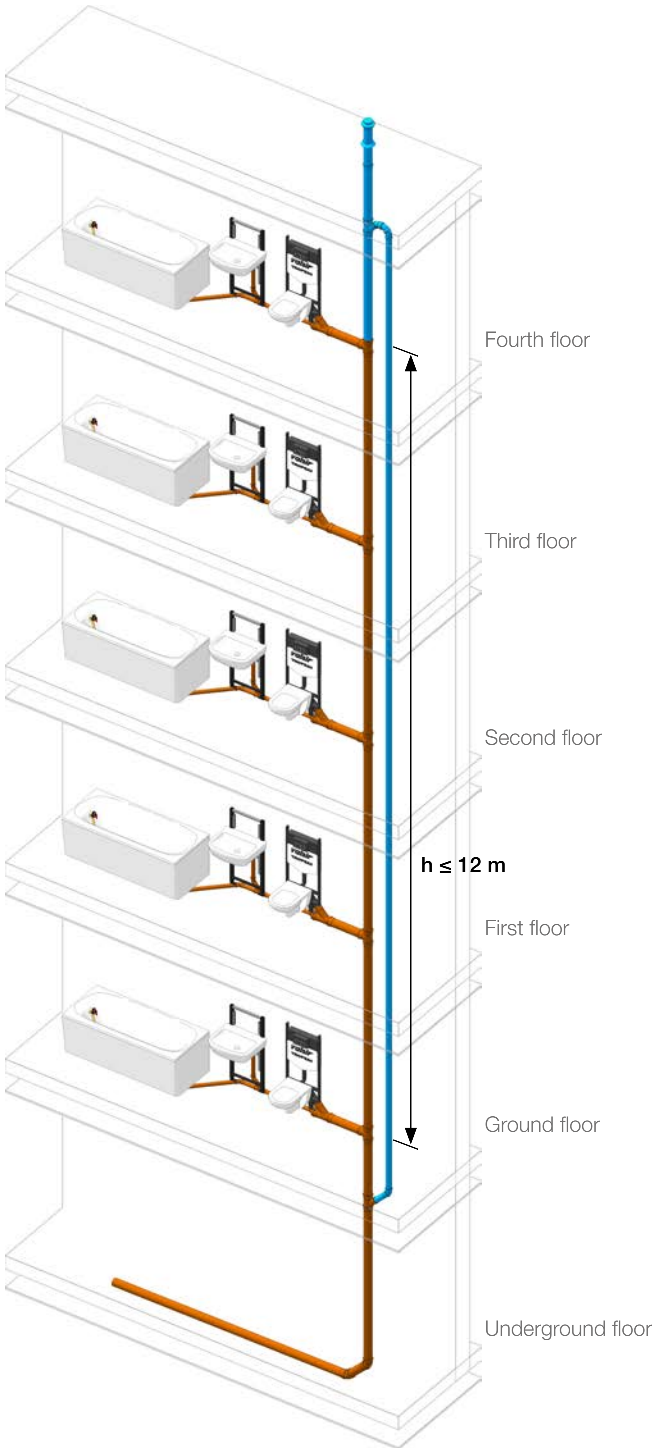
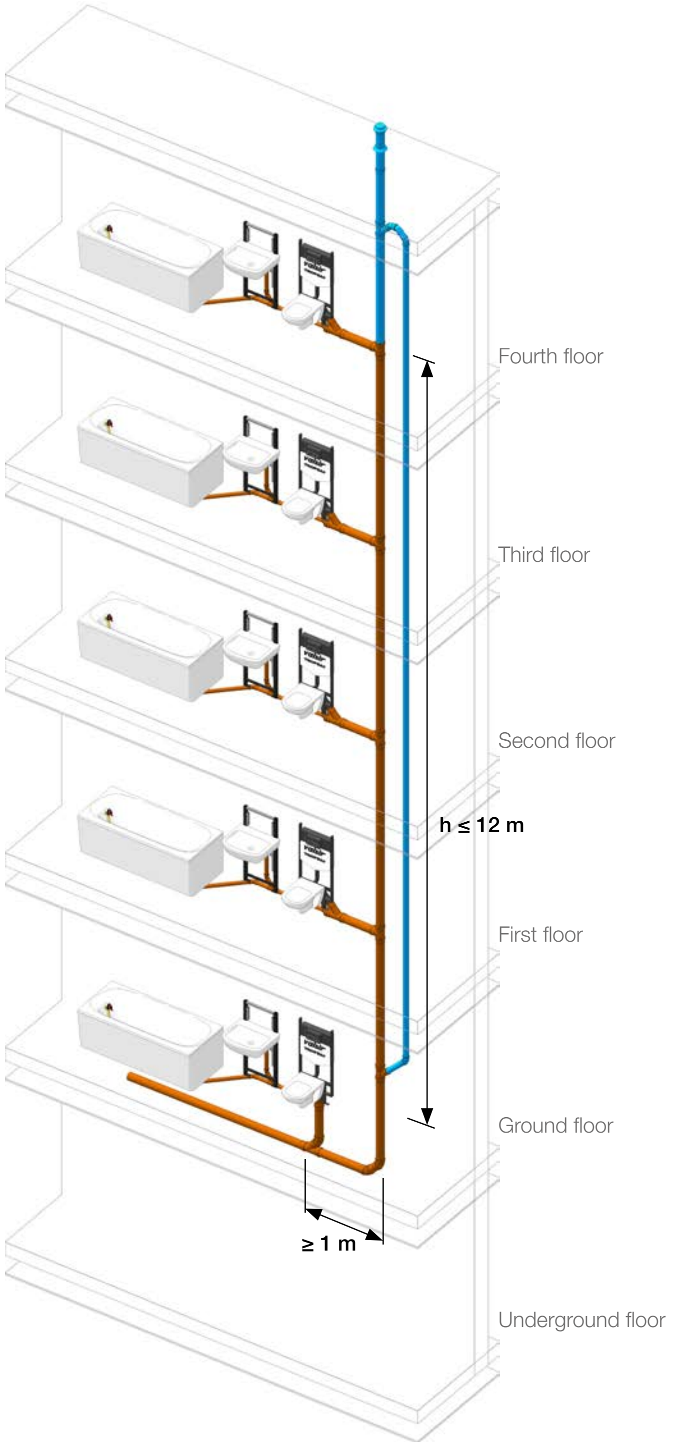


Figure 3.17 Direct parallel vent, 3÷5 storey building (h ≤ 12 m), collector in the ceiling of the underground floor.



3.3.2.2 Direct parallel vent system for buildings with over 5 storeys (h > 12 m)

For buildings with more than 5 floors the parallel vent stack must be connected on each floor by means of intermediate vent connections. If there is an elevated number of floors, the use of intermediate connections can be avoided as long as they are made at intervals of at least four floors.

As with primary ventilation system, again in this case, the fixtures nearest to the foot of the stack must be connected to the waste stack by means of a second stack (splitting) and to favour the ventilation it is necessary to connect it to the main stack by means of a "vent loop". Connection to the collector must be made at a distance of at least 2 meters from the base of the stack. Also for the fixtures connected to the second stack, it is necessary to connect them to the vent stack by means of intermediate connections.

In chapter 3.5.1 criteria are indicated for the division of the stack in relation to the number of floors that need to be served.

Figure 3.18 Direct parallel vent, building with over 5 floors (h > 12 m), collector in the pavement of the underground floor.

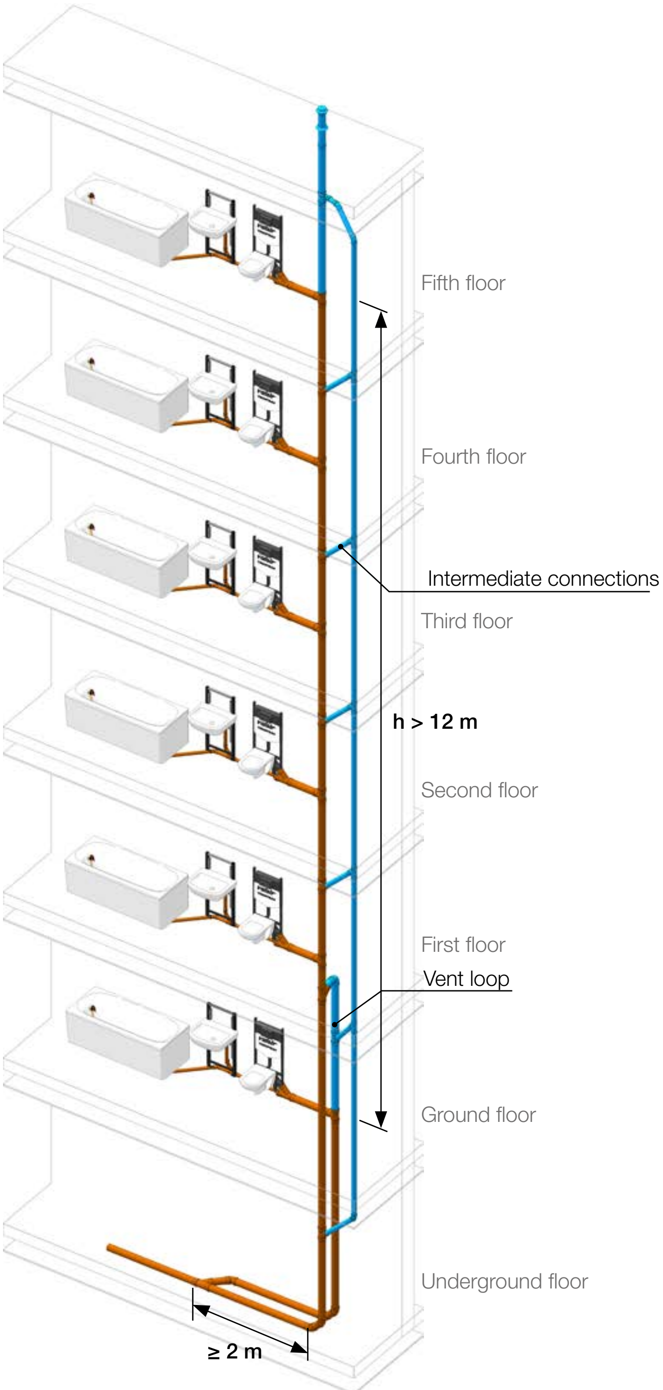
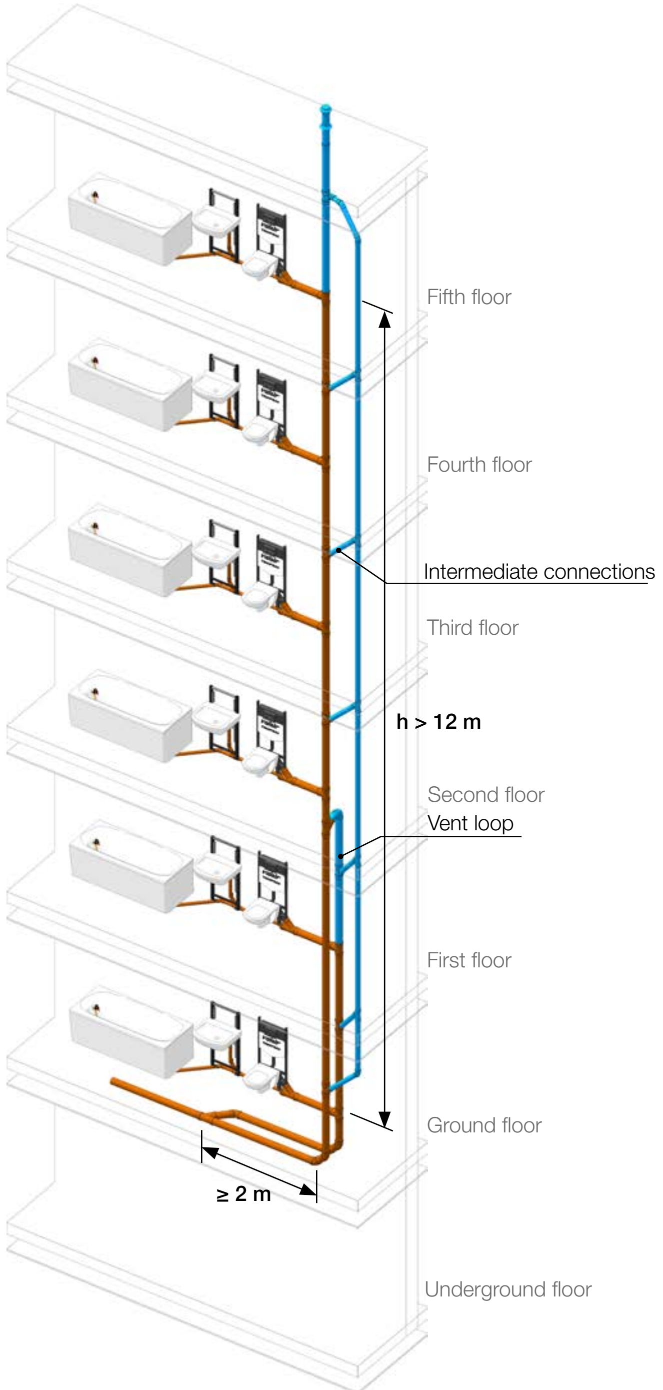


Figure 3.19 Direct parallel vent, building with over 5 floors (h > 12 m), collector in the ceiling of the underground floor.



3.3.2.3 Indirect parallel vent system

The geometrical configuration of the indirect parallel vent stack does not depend on the number of floors; it is connected to the waste branches and is used when the distance between the most distant fixture and the waste stack exceeds 4 m. This system is employed when the fixtures are arranged in rows, in buildings such as schools, barracks, etc. In any case, to avoid the rising of foam, the connection of each floor to the waste stack must observe the criteria as indicated for direct parallel vent systems (see the chapter 3.5.1).

When the length of the branches exceeds 10 m, it is recommended to use intermediate vents connected halfway along the waste branches (see Figure 3.24).

Figure 3.20 Indirect parallel vent, 3÷5 storey building (h ≤ 12 m), collector in the pavement of the underground floor.

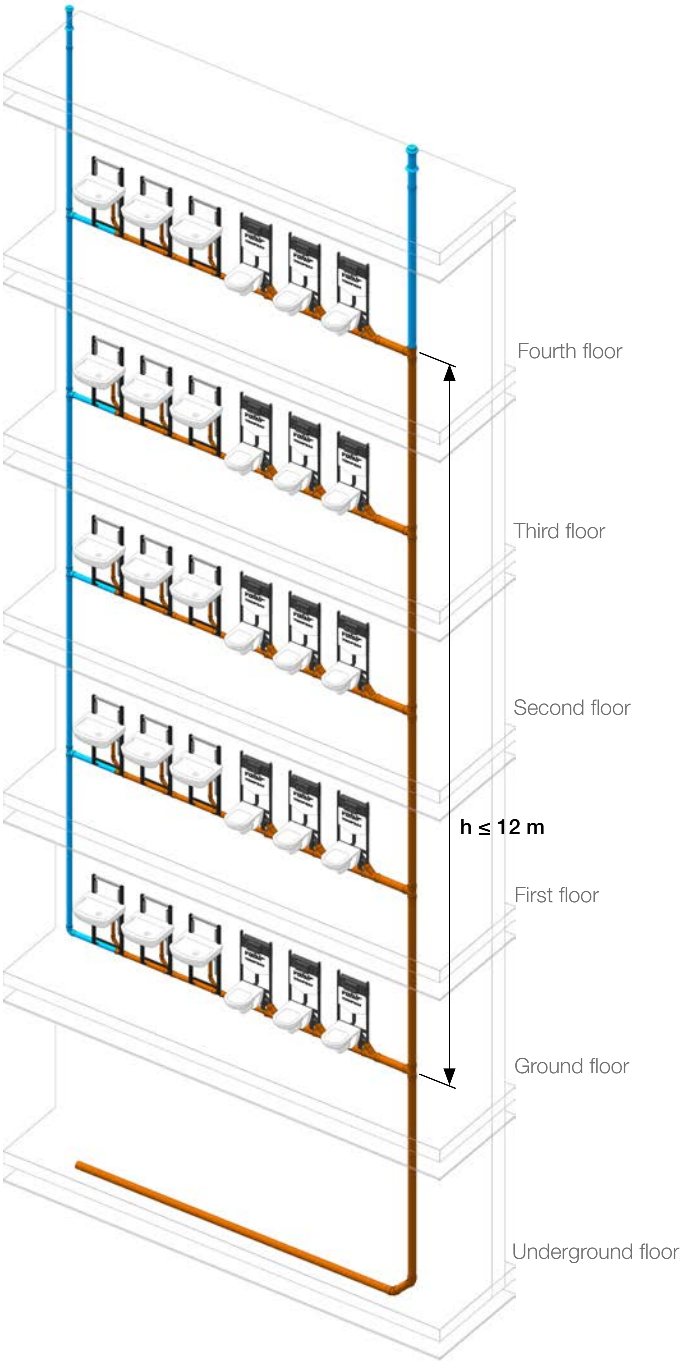


Figure 3.21 Indirect parallel vent, 3÷5 storey building (h ≤ 12 m), collector in the ceiling of the underground floor.

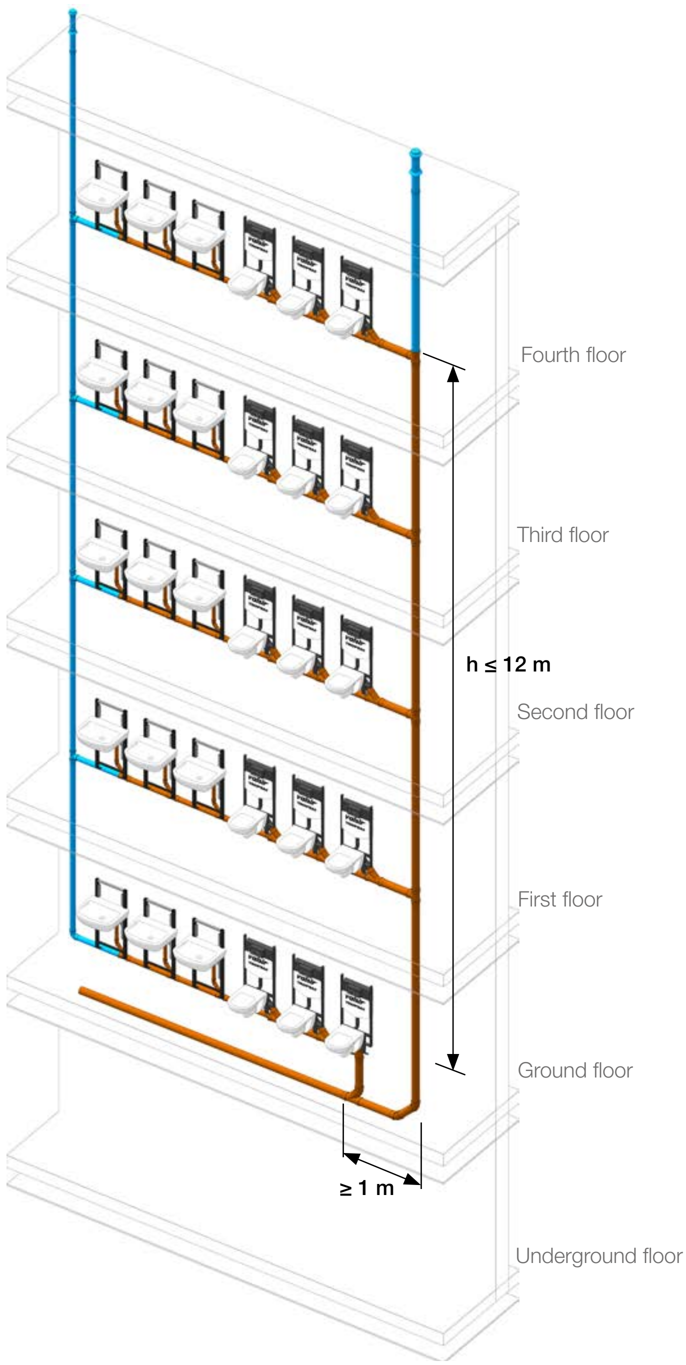


Figure 3.22 Indirect parallel vent, building with over 5 floors (h > 12 m), collector in the pavement of the underground floor.

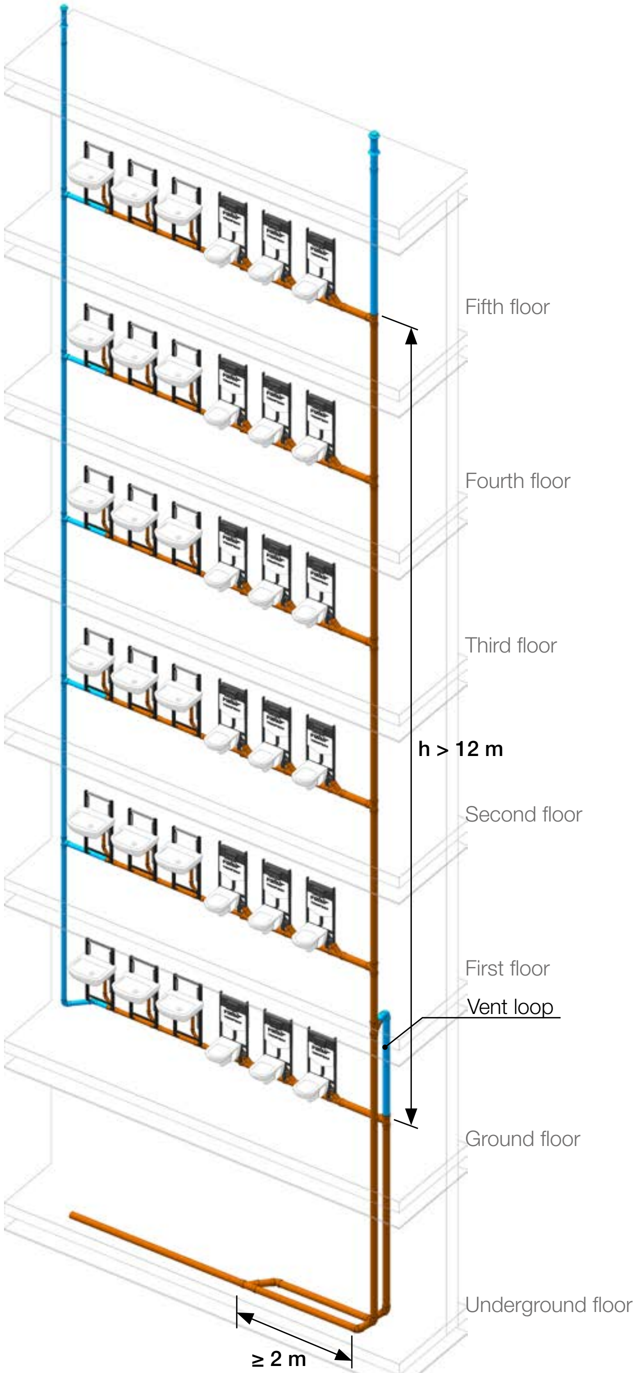


Figure 3.23 Indirect parallel vent, building with over 5 floors (h > 12).

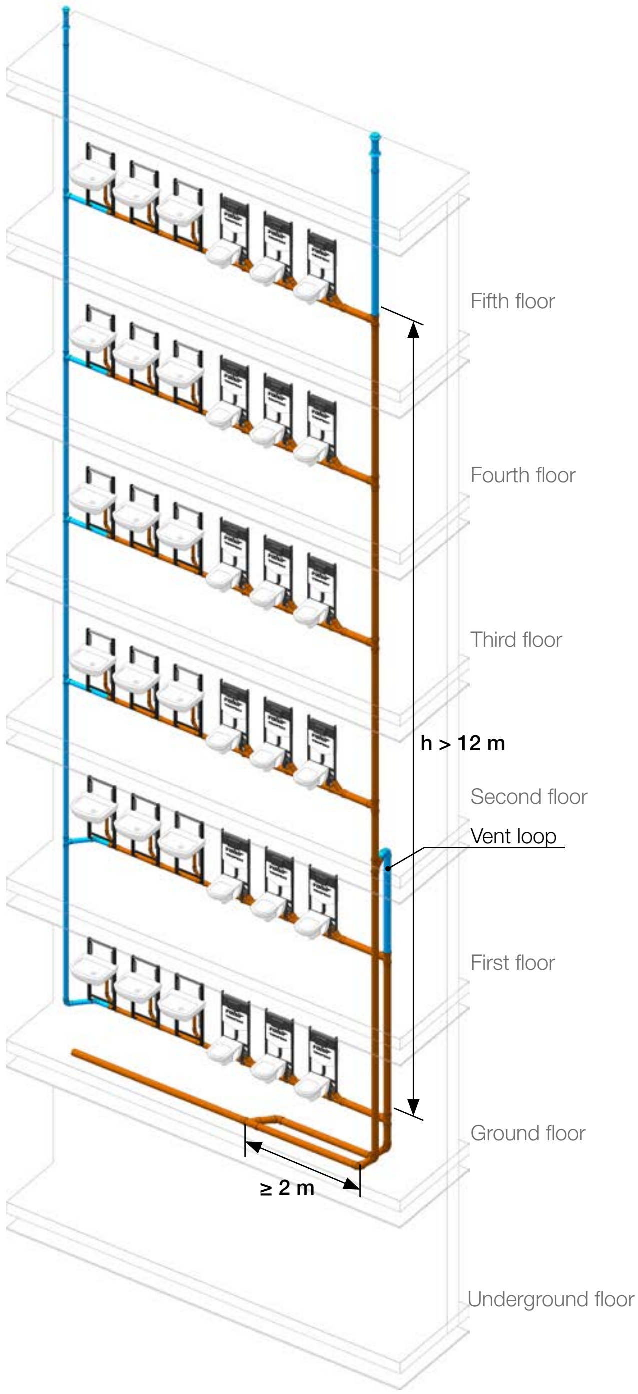
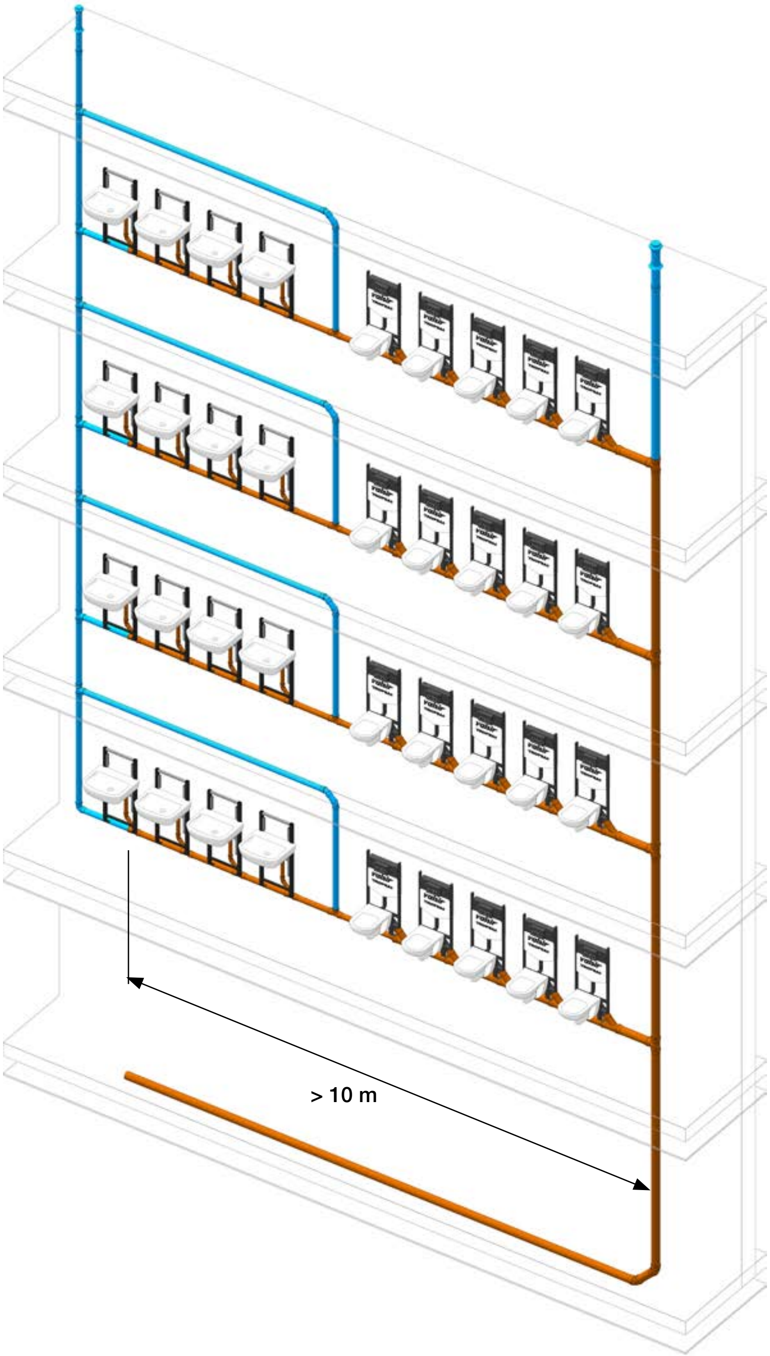


Figure 3.24 Indirect parallel vent, intermediate ventilation of the branches with lengths of over 10 m.



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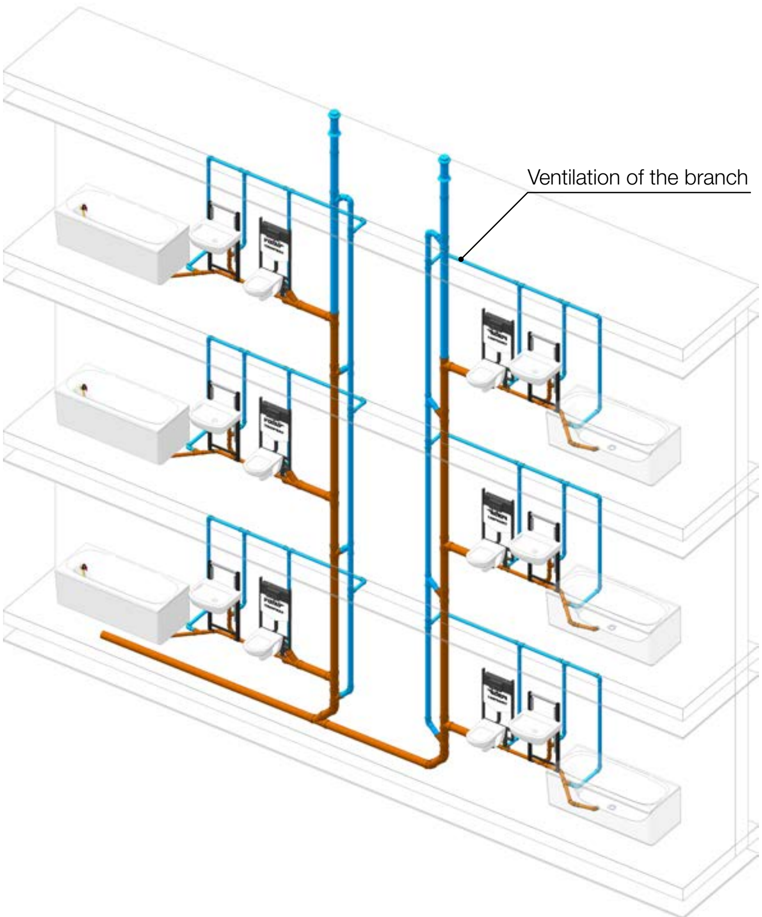
3.3.3 Waste systems with secondary ventilation

This type of system is made up of a vent stack that runs parallel to the waste stack. A ventilation network is connected to the waste stack and to all of the fixtures by means of a spigot bend or trap (branch ventilation). As with the other systems, the waste stack is extended to the roof (relief vent) or, in alternative, it ends in the room by means of an aeration valve. Like for the parallel ventilation systems, depending on the number of floors to be served, the ventilation stack can have intermediate connections with the waste stack that ensure a better circulation of the air inside the network.

Characteristics of secondary ventilation systems:

- Expensive, not only because of the quantity of material required, but also due to the complexity of the system.
- Suitable in very tall buildings where fixtures are used contemporarily.
- Suitable where sanitary fixtures and stacks are positioned along the same wall in that any windows, doors, openings, spigots, would compromise the possibility of ventilating the fixtures by connecting them to the vent stack.
- As in the parallel ventilation system, it is possible to increase the flow rates of the waste stack by 30-40% as compared with primary ventilation systems and the flow rates of the branches by 50% (see the chapter on waste system sizing).
- The European Standard UNI EN 12056 sets a minimum diameter for parallel vent stacks in relation to the diameter of the waste stack (see the chapter on waste system sizing).
- The diameters of the vent pipes of the branches are specified in the European Standard UNI EN 12056 (see chapter on waste system sizing).
- The branches can reach 10 m with minimum gradients of 0.5% (for more details, refer to the chapter on waste system sizing).

Figure 3.25 Waste system with secondary ventilation.



3.3.4 Waste systems with ventilation fittings

It is a waste system made with special fittings called ventilation branch fittings, that does not require the use of the parallel ventilation system described above and, at the same flow rate, allows to reduce the diameter of the waste stacks.
While sizing of branches and collectors must comply with the methods established by the European Standard UNI EN 12056-2, calculation of the vertical waste stacks equipped with ventilation fittings, requires the application of special rules that are described in the chapter that deals with the sizing of waste systems with ventilation fittings.

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The characteristics that distinguish systems with ventilation fittings are the following:

- It is a system suitable in tall buildings or where drain flows and contemporaneity factors are high (hotels, barracks, office buildings, schools, hospitals, etc.).
- It is extremely cost-effective in buildings higher than 7 to 8 storeys.
- It does not require any parallel ventilation, the vertical waste stack is simply extended out onto the roof (as with primary ventilation).
- It allows to increase flow rates in waste stacks to more than double that of a parallel, or secondary, ventilation system with the same diameter.
- It significantly reduces pressure fluctuations inside the vertical waste stack thanks to the particular shape of the ventilation fitting.
- Just two waste stack sizes in relation to the waste water flows: DN 100 (OD 110 mm) and DN 150 (OD 160 mm).

Figure 3.26 Waste system with ventilation fittings.

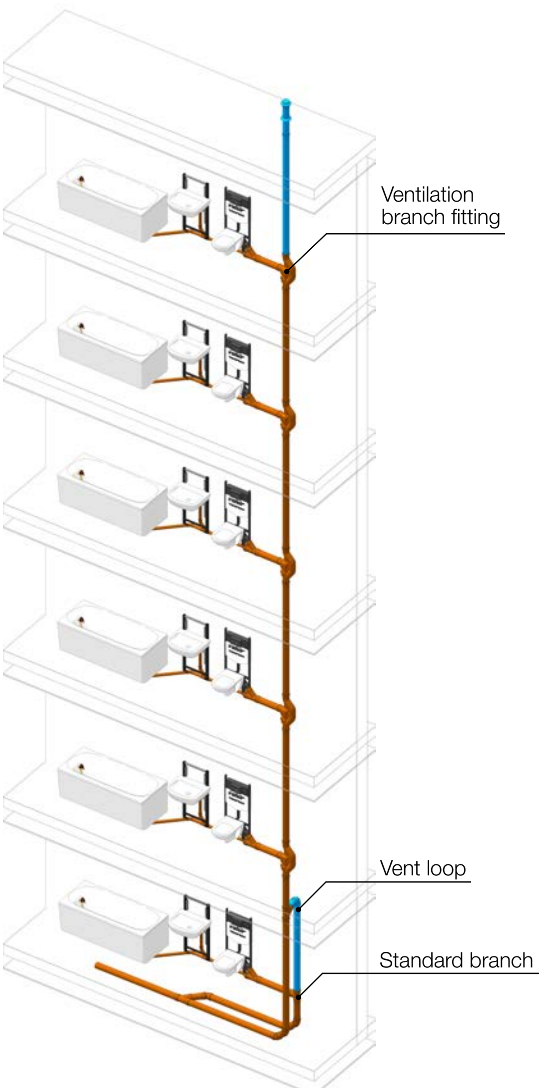
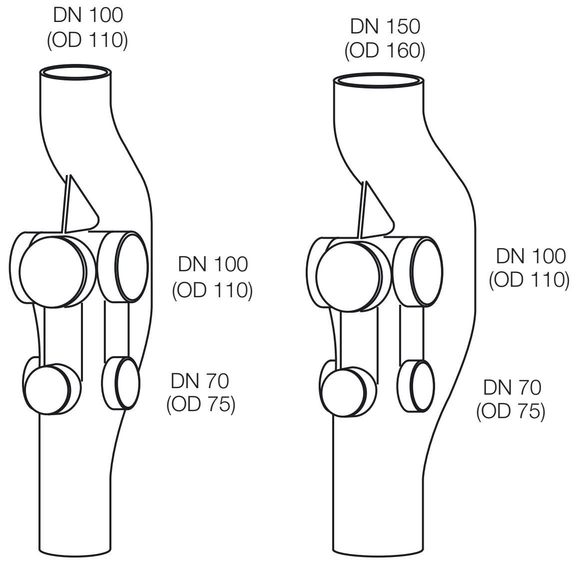


Figure 3.27 The two ventilation fitting models manufactured by Valsir.



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3.3.5 Guideline in the choice of the waste system

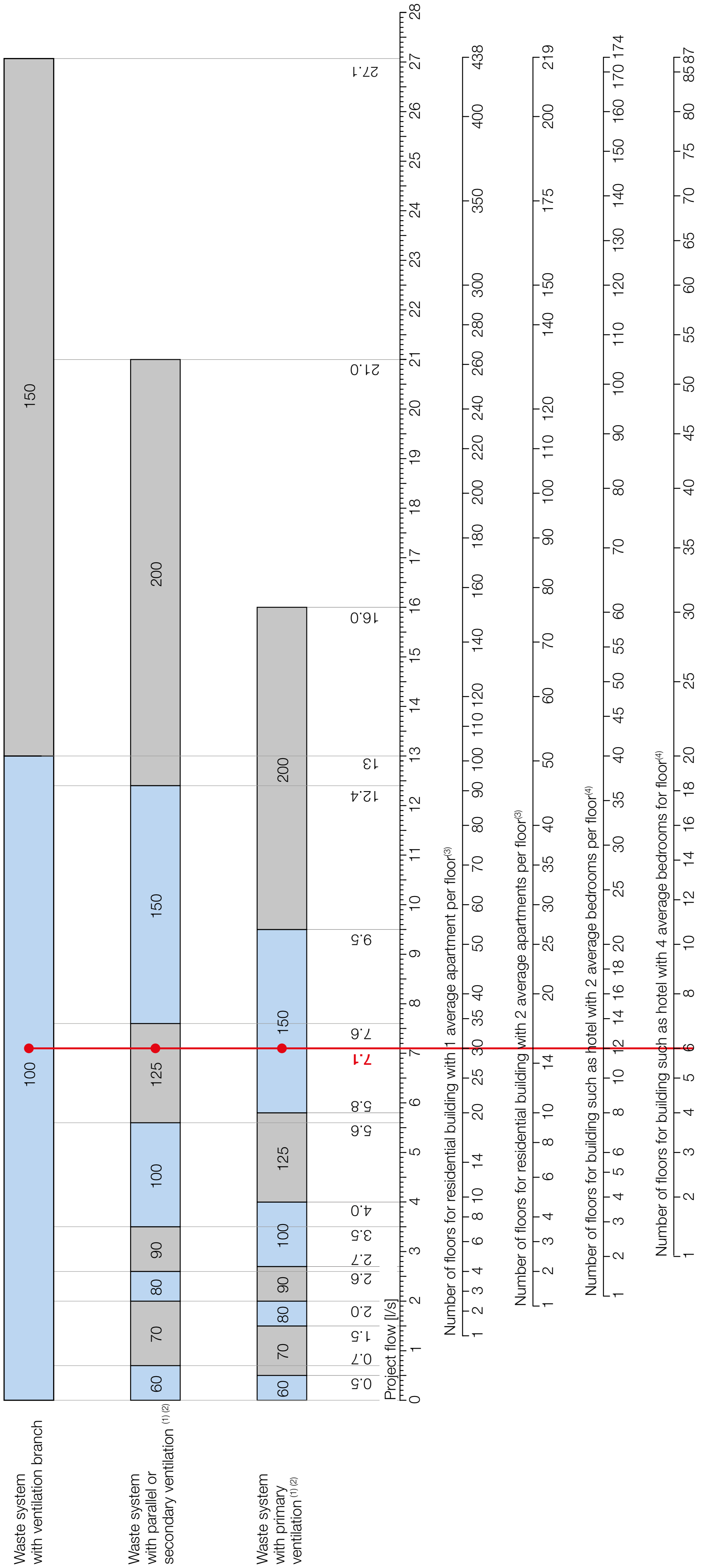
To rapidly identify the diameter of the vertical waste stack in relation to the system chosen, it is possible to consult the diagram in Figure 3.28. Once the project flow has been determined or the number of storeys in the building is known as well as the building type, the waste stack diameter to be adopted in relation to the system is rapidly identified: primary ventilation, parallel or secondary ventilation, ventilation with branch ventilation fittings.

Vice versa, once the ventilation system has been defined, it is possible to evaluate the maximum project flow or the maximum number of floors in the buildings in relation to the diameter of the vertical waste stack.

Example

Let's suppose we have a project flow of 7.1 l/s. With a primary ventilation system the diameter of the stack must be 150 mm, with a primary or secondary ventilation system the diameter must be 125 mm, while with a system with a ventilation branch fittings the diameter can be reduced to 100 mm.

Figure 3.28 Choice of the waste system.



NOTE
(1) DN 100 is the minimum diameter to be guaranteed in the presence of a water closet.

(2) Valid diameters for waste stacks with right angle branches (single or double).

(3) An average apartment is composed of 1 WC, 1 bidet, 1 washbasin, 1 bathtub, 1 washing machine, 1 sink, 1 dishwasher with ∑DU = 6.7 l/s. The number of floors is indicative in that, for very high buildings, waste stacks splitting is always recommended.

(4) An average bedroom is composed of 1 WC, 1 bidet, 1 washbasin, 1 bathtub with ∑DU = 4.3 l/s. The number of floors is indicative, in that, for very high buildings, waste stack segmentation is always recommended.

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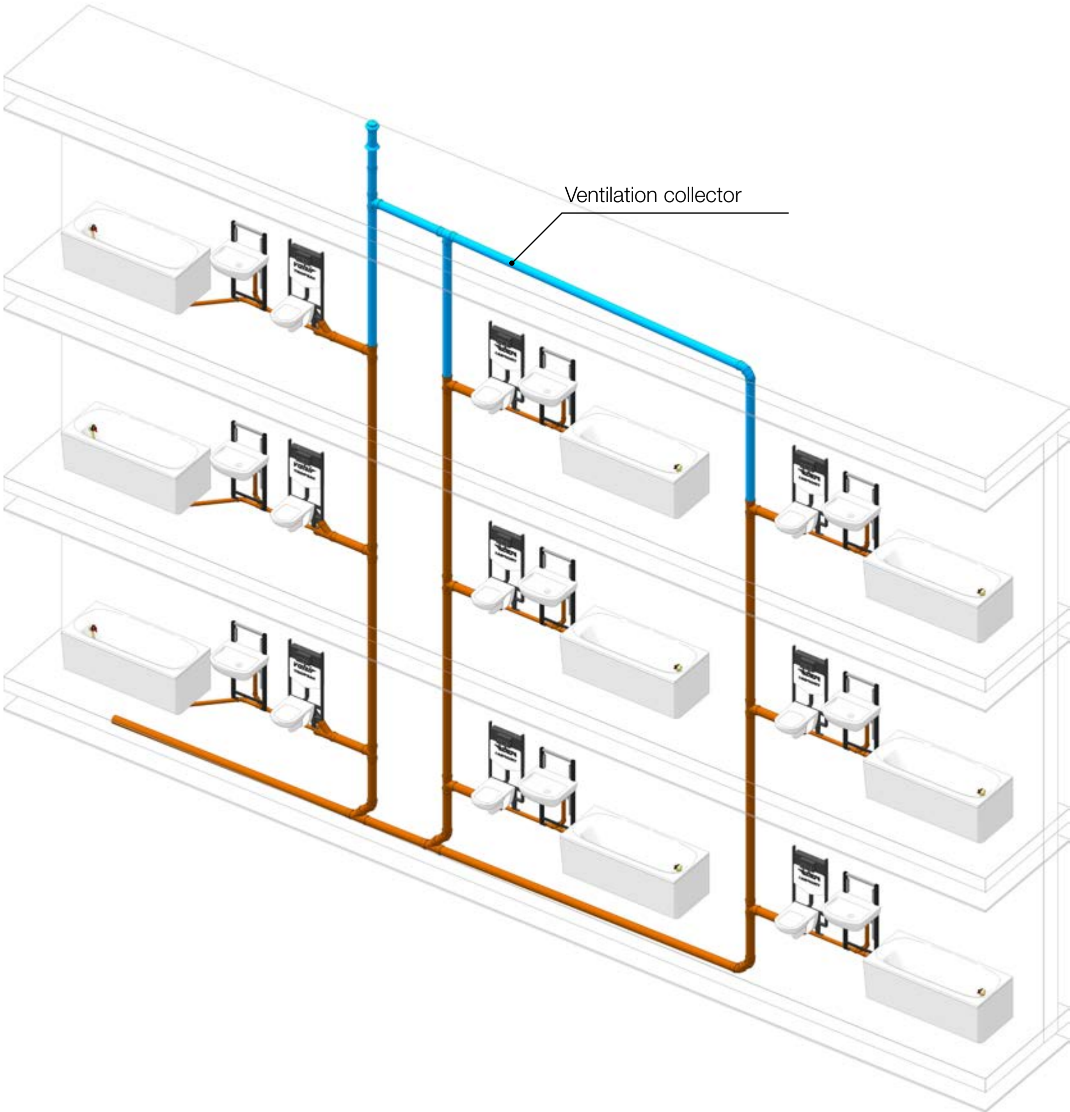
3.3.6 Common sections or ventilation offsets in waste systems

For any waste system described in the previous chapters, the ventilation stack axis can be moved laterally to avoid obstacles or to exit through the roof or the wall, in parts of the building that are less problematic. It is also possible to connect several ventilation stacks in order to exit through the roof with a lower number of pipes.
The sizing of common sections or ventilation movements for various waste systems, excluding the one with ventilation branch fittings, follows the specific rules described in chapter 4.6.
The sizing of common sections or ventilation offsets for waste systems with ventilation branch fittings follows the specific rules described in chapter 5.3.3.
For installation of horizontal ventilation sections, it is suggested to provide a slope of at least 0.5% towards the waste stacks. Even if this does not affect the drainage capacity of the system, it is important to facilitate the evacuation of condensation that may create inside the pipes.

Figure 3.29 Ventilation collector.



3.4 Waste branches

The waste branches are made up of mainly horizontal pipes that connect sanitary fixtures to the waste stacks. When installing waste branches, several basic rules should be observed:

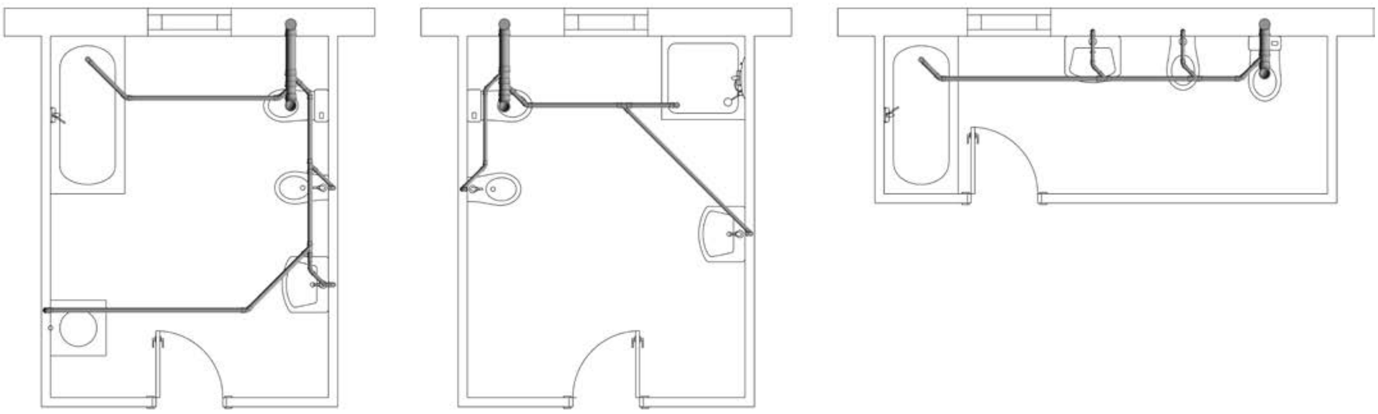
- Pipes' diameter and length must ensure the absence of siphonage and self-siphonage phenomena. If there is the risk that these phenomena occur, it is necessary to provide a ventilation network of waste branches.
- The branches' slope must be in the direction of the drain flow. Slope values must be less than 5%, with unvented branches requiring a minimum of 1% and vented branches requiring a minimum of 0.5% (for more information, see the chapter on exhaust system sizing).
- Offsets must be kept to a minimum and in any case realized with a sufficiently wide radius to avoid slowing down the waste flow.
- Avoid using diameters that are smaller than the connection to the siphon.
- The meeting point of several waste pipes in a branch must be made avoiding 90° angles.
- The passage toward greater diameters must be made by employing concentric reducers or eccentric reducers, but keeping the upper part of the pipes straight.

For more details on project requirements for waste branches, refer to the chapter on waste systems sizing.

3.4.1 Direct waste branch

It is the most common method used for waste branches. It is made by connecting all sanitary fixtures to a pipe that is connected to the waste stack. Couplings to this pipe are made with 45° branch fittings that facilitate the flow in the stack direction.
The benefits of this solution are the reduced vertical overall dimensions, the limited need of items and the possibility of connecting several sanitary fittings to the same pipe section.

Figure 3.30 Examples of direct waste branch.



3.4.2 Waste branch through a gully trap

It is a type of system particularly used in countries where installation of a trap inside the room is required in order to drain the water used to clean the room, or resulting from any leaks from sanitary fixtures.
It consists in positioning a gully trap inside the room that can convey both water from a grille on the upper side of the gully trap, and water from pipes used by the sanitary fixtures inside the room (excluding the WC) connected to the side of the various trap inlets.
If necessary, the grille on the upper side can be used as drainage for a shower.
The gully trap can be installed either inside the screed of the relevant floor or suspended below the slab of the lower floor.
In addition to managing any water leaks from sanitary fixtures, the benefits of this system are the easy maintenance of waste branches and, if the trap is equipped with siphon, the possibility of removing siphons used on every single sanitary fixture.

Figure 3.31 Example of waste branch with T-Trap used as trap inside the room and fixed to the slab of the lower floor.

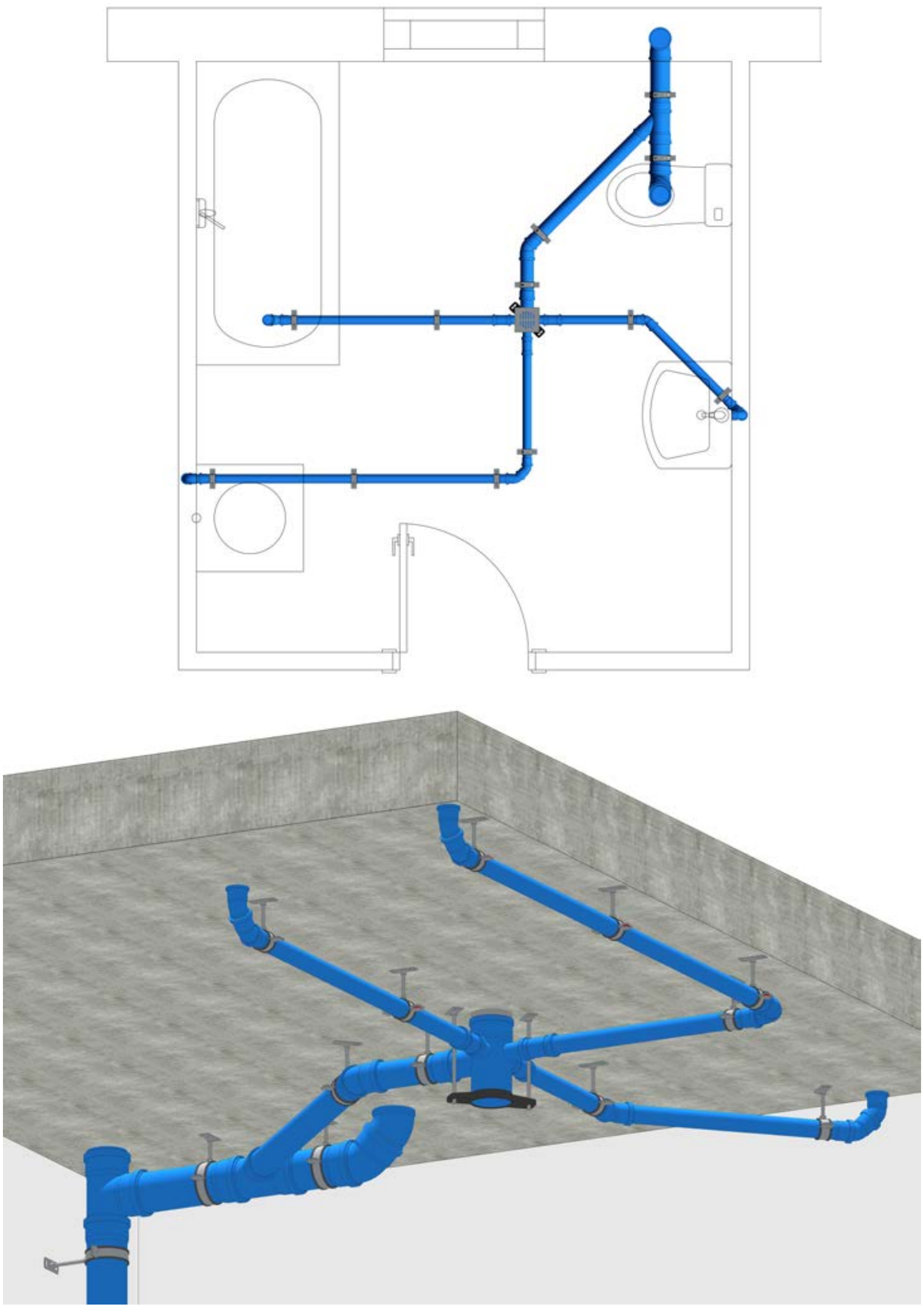
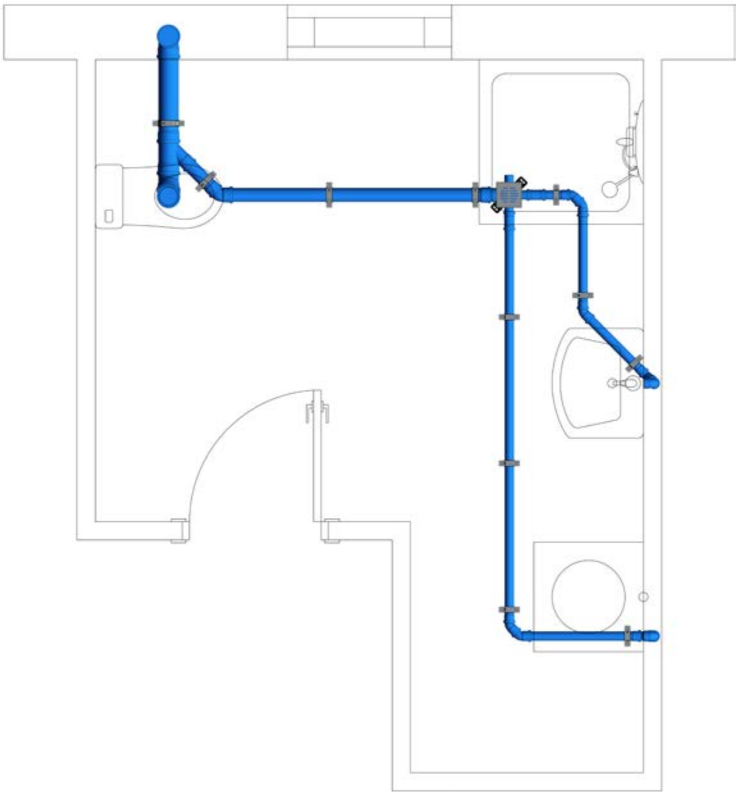


Figure 3.32 Example of waste branch with T-Trap used as shower drainage and fixed to the slab of the lower floor.



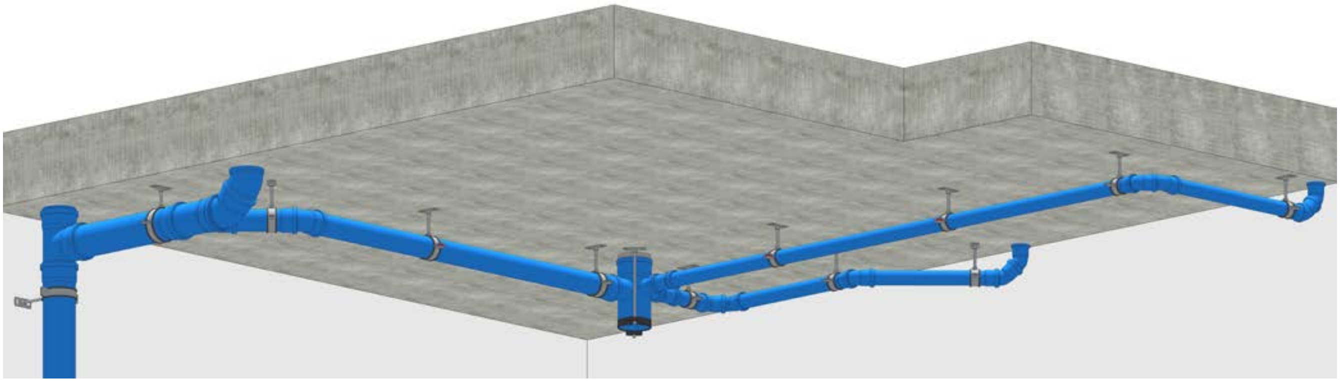


Figure 3.33 Example of waste branch with trap in Triplus H170 installed inside the screed.

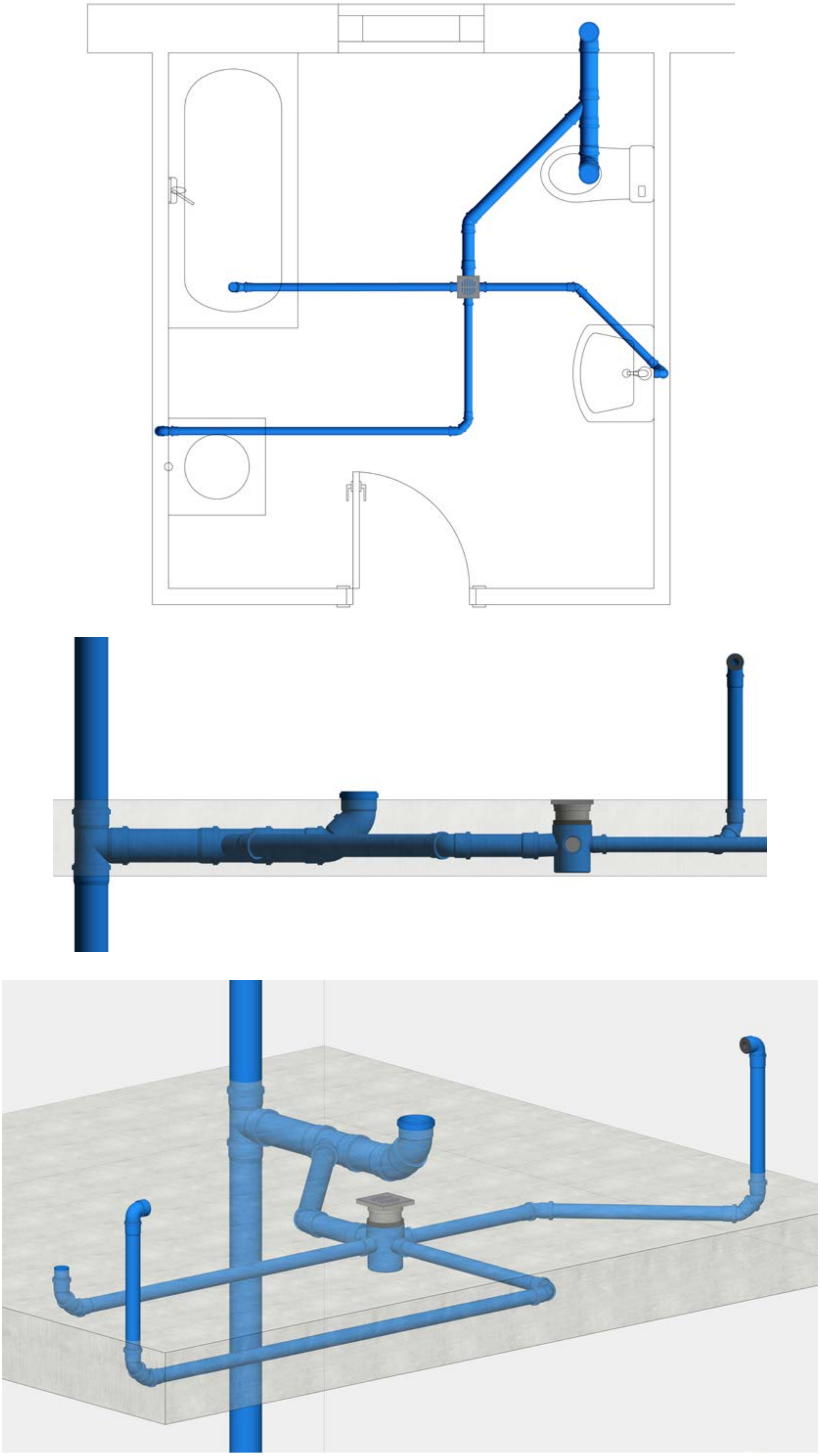
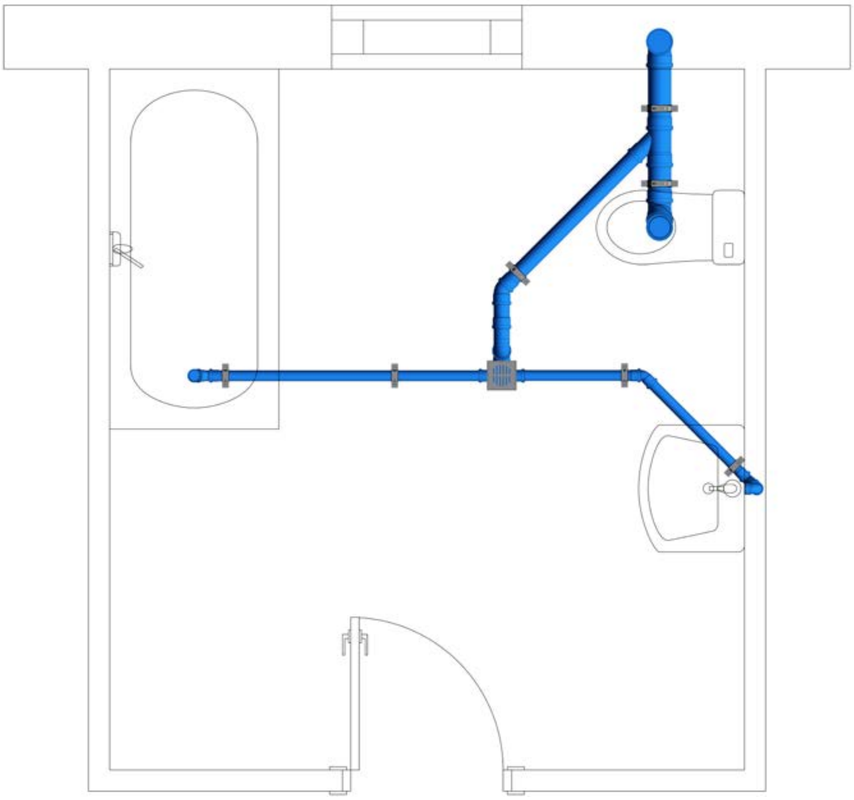
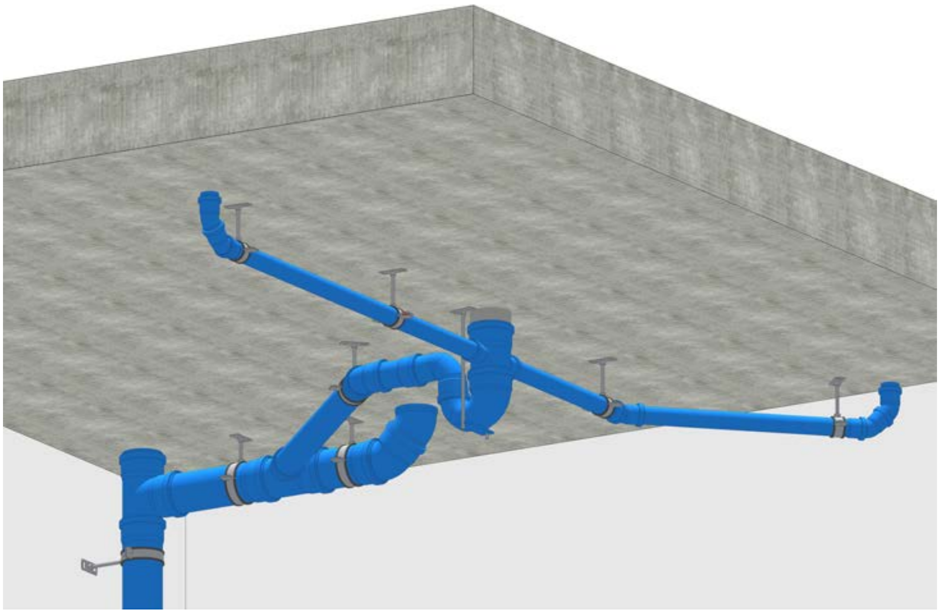


Figure 3.34 Example of waste branch with P-Trap used as gully trap inside the room and fixed to the slab of the lower floor.





3.5 Waste stacks

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3.5.1 Division of waste stacks

In previous chapters, in some cases we noted the necessity of splitting the waste stack, whether it is ventilated with a direct, indirect, parallel or secondary ventilation system. The splitting of the stack and its height depend on the total number of floors connected to the waste system and on the position of the collector.

Valsir suggests using the configurations indicated in the following tables; these are not the only feasible ones available, but just some of the numerous project choices that can be adopted.

In the tables, depending on the number of floors connected to the waste system, it is possible to verify if the stack needs to be divided and to determine the number of floors that can be connected to the main stack and those that need to be connected to the second stack. Furthermore, since in some cases even the second stack can reach elevated heights, another splitting shall be made.

Table 3.1 Configuration of the waste stack with collector in the pavement of the underground floor.

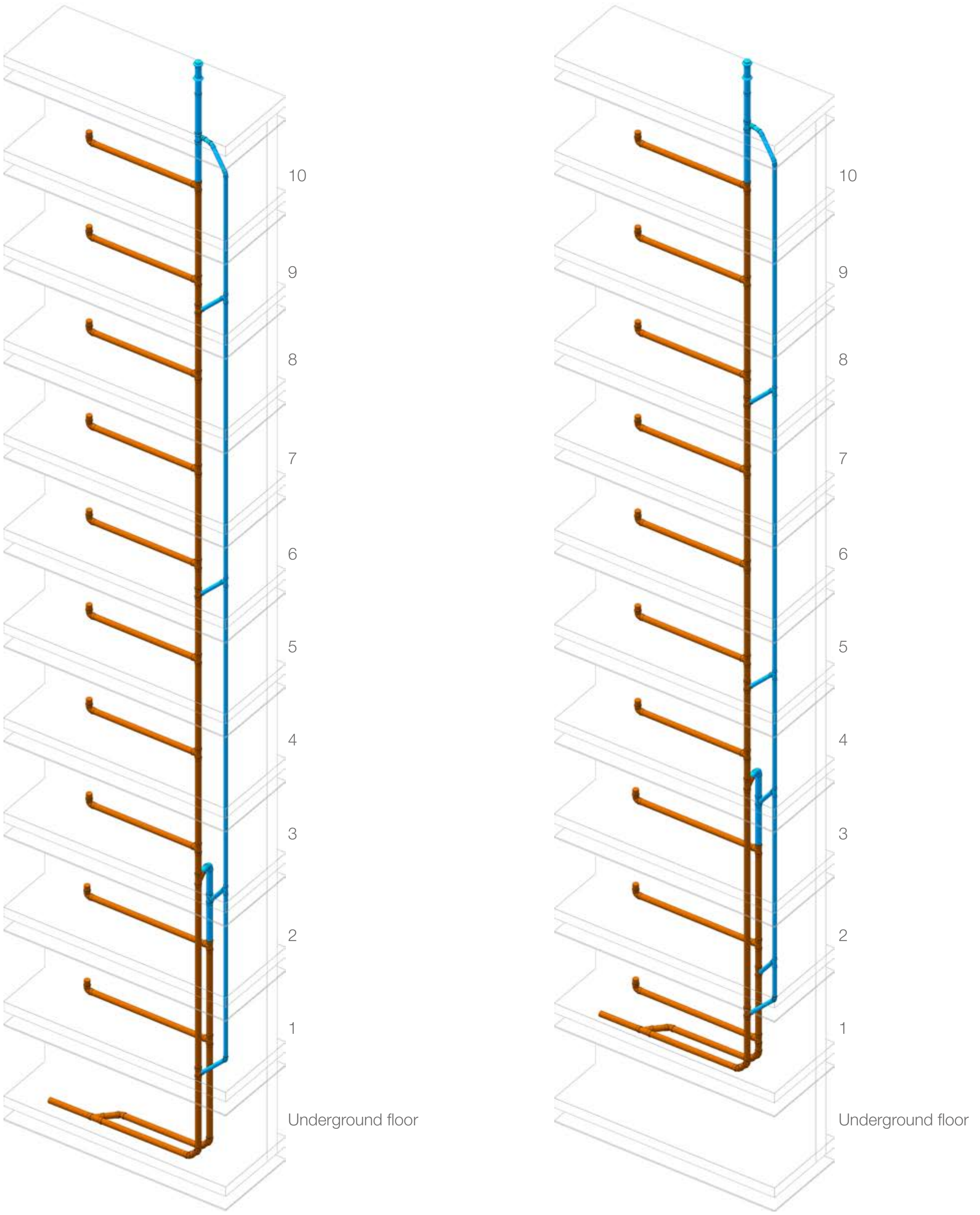
Floors (incl. ground floor)	Stack splitting?	Number of floors connected to the main stack	Number of floors connected to the second stack	Further splitting of the second stack?
3	No	3	0	No
4	No	4	0	No
5	No	5	0	No
6	Yes	5	1	No
7	Yes	6	1	No
8	Yes	7	1	No
9	Yes	7	2	No
10	Yes	8	2	No
11	Yes	9	2	No
12	Yes	9	3	No
13	Yes	10	3	No
14	Yes	11	3	No
15	Yes	11	4	No
16	Yes	12	4	No
17	Yes	13	4	No
18	Yes	13	5	No
19	Yes	14	5	No
20	Yes	15	5	No
21	Yes	15	6	Yes
22	Yes	16	6	Yes
23	Yes	17	6	Yes
24	Yes	17	7	Yes
25	Yes	18	7	Yes

Table 3.2 Configuration of the waste stack with collector on the ceiling of the underground floor.

Floors (incl. ground floor)	Stack splitting?	Number of floors connected to the main stack	Number of floors connected to the second stack	Further division of the second splitting?
3	No	3	0	No
4	No	4	0	No
5	Yes	4	1	No
6	Yes	4	2	No
7	Yes	5	2	No
8	Yes	6	2	No
9	Yes	6	3	No
10	Yes	7	3	No
11	Yes	8	3	No
12	Yes	8	4	No
13	Yes	9	4	No
14	Yes	10	4	No
15	Yes	10	5	Yes
16	Yes	11	5	Yes
17	Yes	12	5	Yes
18	Yes	12	6	Yes
19	Yes	13	6	Yes
20	Yes	14	6	Yes
21	Yes	14	7	Yes
22	Yes	15	7	Yes
23	Yes	16	7	Yes
24	Yes	16	8	Yes
25	Yes	17	8	Yes

Some examples of waste systems with direct parallel ventilation are shown in the figures below. The same configurations apply to systems with indirect and secondary ventilation.
A building with 10 floors connected to the waste system requires the stack split. If the collector is installed on the basement floor, the highest 8 floors are connected to the main stack, while the other 2 floors are connected to the second stack. In this case, intermediate connections to ventilation can be positioned every 2-3 floors. If the collector is installed on the basement ceiling, 3 floors must be connected to the second stack because of the greater risk of foam rising.

Figure 3.35 Example of system with 10 floors with direct parallel ventilation (collector in the pavement and on the ceiling).



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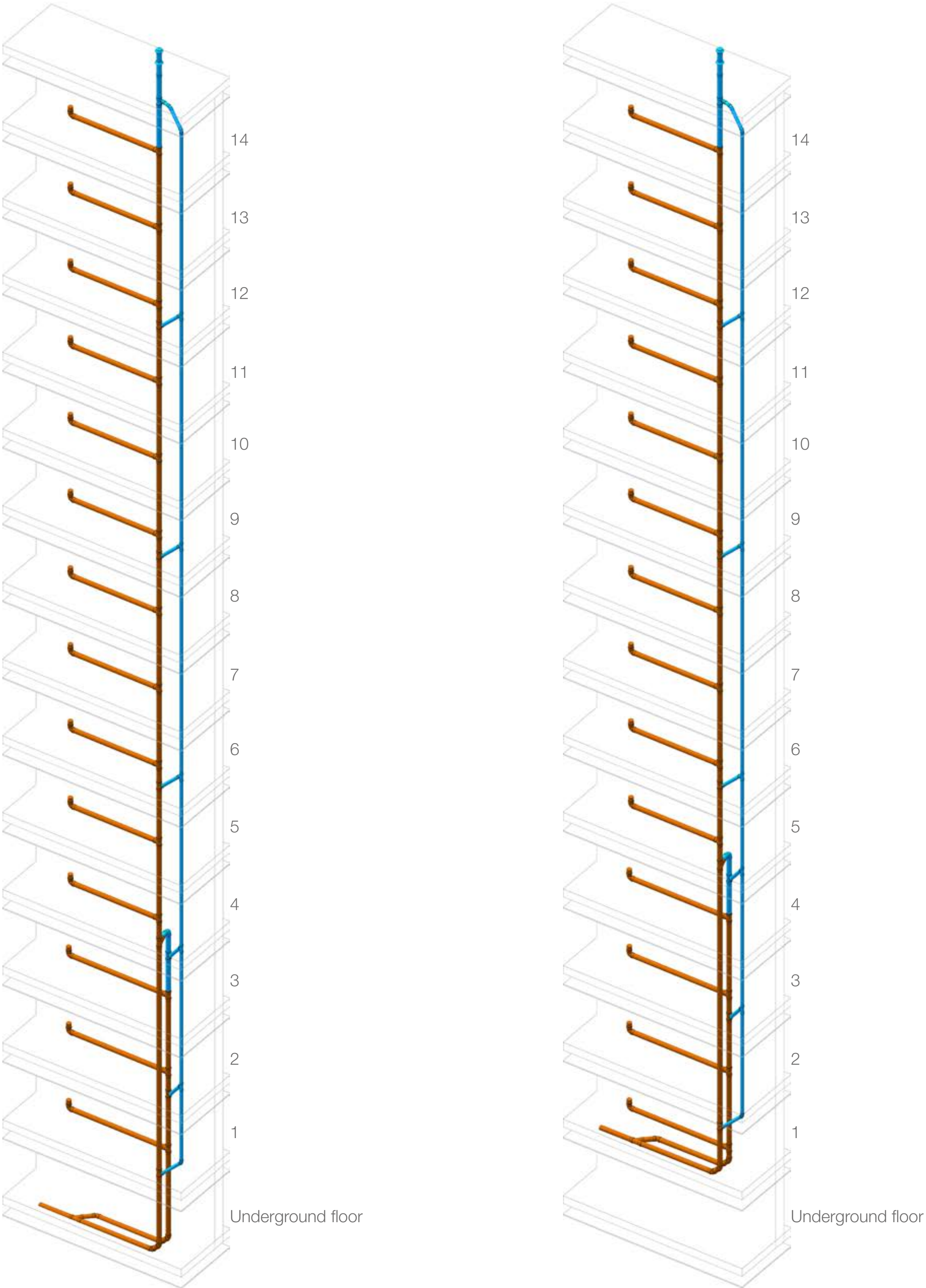
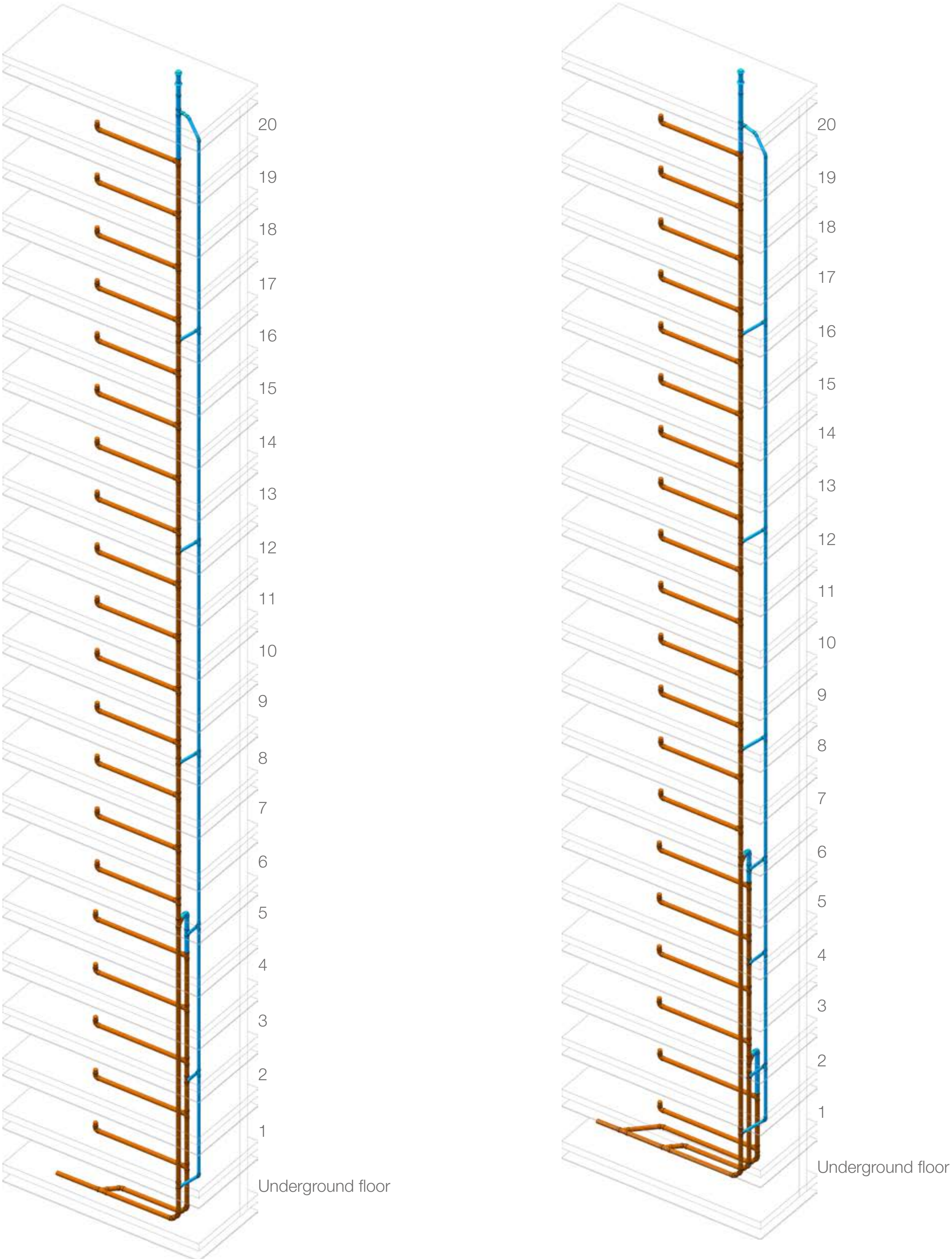
A building with 14 floors connected to the waste system also requires the main stack split. If the collector is installed on the basement floor, the highest 11 floors are connected to the main stack, while the other 3 floors are connected to the second stack. Intermediate connections to ventilation can be positioned every 2-3 floors. If the collector is installed on the basement ceiling, 10 floors must be connected to the main stack and the other 4 floors must be connected to the second stack.

Figure 3.36 Example of system with 14 floors with direct parallel ventilation (collector in the pavement and on the ceiling).



Finally, consider a building with 20 floors connected to the waste system. If the collector is installed on the basement floor, 15 floors are connected to the main stack and the other 6 floors are connected to the second stack. In case of collector installed on the basement ceiling, the main stack is connected to the highest 14 floors, while the other 6 floors must be connected to the secondary stack. In this case the stack split is required by moving the first two floors on a further independent stack, and it is possible to create intermediate connections to ventilation every 4 floors.

Figure 3.37 Example of 20-storey building with direct parallel ventilation (collector in the pavement and on the ceiling).

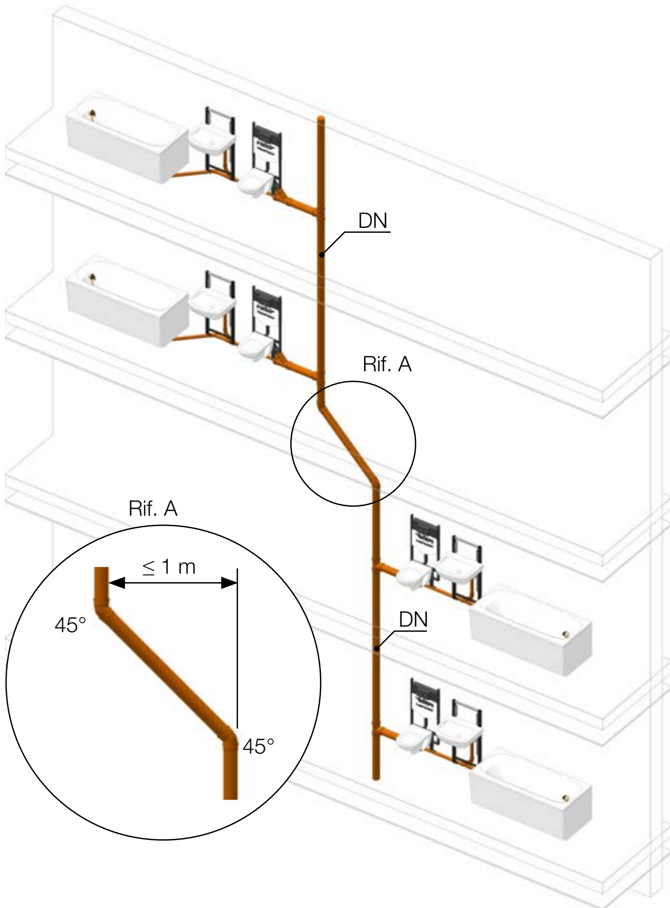


3.5.2 Waste stack deviation

Where, for reasons of space or building configuration, it is necessary to made deviations of the stack, these must respect some fundamental requirements:

- The deviation must be no greater than 1 m, so that in the oblique piece the flow does not undergo accelerations that would create noise caused by the impact against the stack near the change of direction.
- The bends used to create the deviation must be no greater than 45°; the use of bends with bigger angles would increase the noise in proximity to the change of direction.

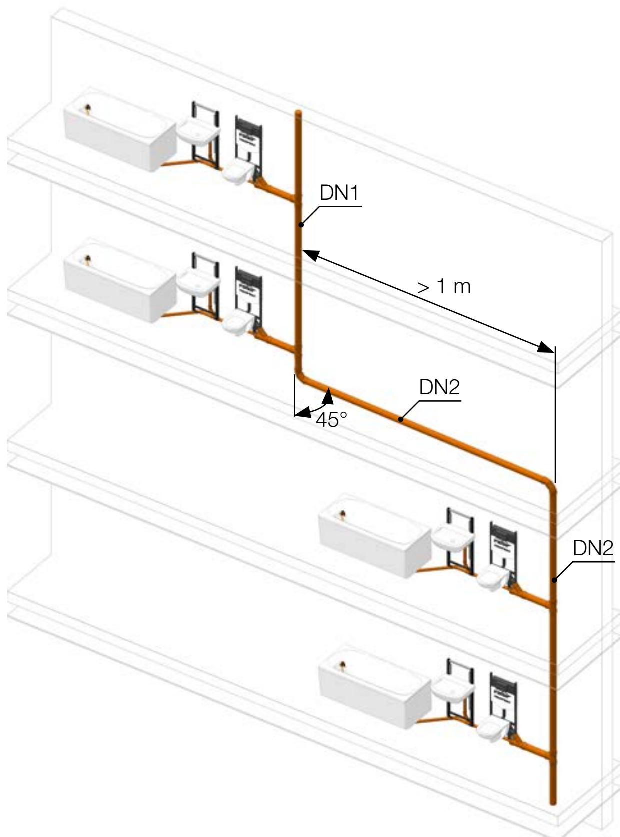
Figure 3.38 Deviation of the waste stack under 1 m.



If the deviation of a stack with a diameter of DN1 requires changes of direction greater than 45° or horizontal pieces longer than 1 m, then the following constraints would have to be respected:

- The horizontal section must be dimensioned like a waste collector, keeping flow velocity no smaller than 0.6 m/s to avoid the separation of the solid substances in the flow.
- The stack lying below must have a diameter of DN2 equal at least to the waste collector.

Figure 3.39 Deviations of the waste stack greater than 1 m and direction changes greater than 45°.



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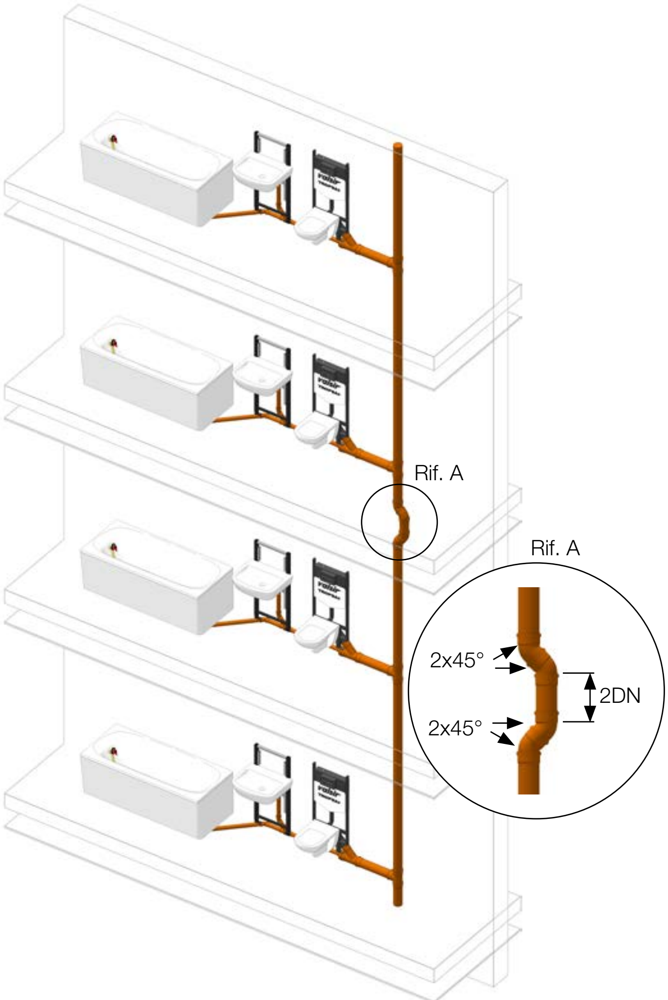
Deviations of the stack can also be used to limit flow speed in the down pipe and to reduce noise levels in the waste system. In this case, the deviation of the stack needs to be corrected in a relatively short stretch restoring the down pipe to its original axis.
The deviation should be created:

- Using 4 x 45° bends and, in between, a vertical stretch with a length that is twice the nominal diameter of the down pipe.
- Every 4 floors.

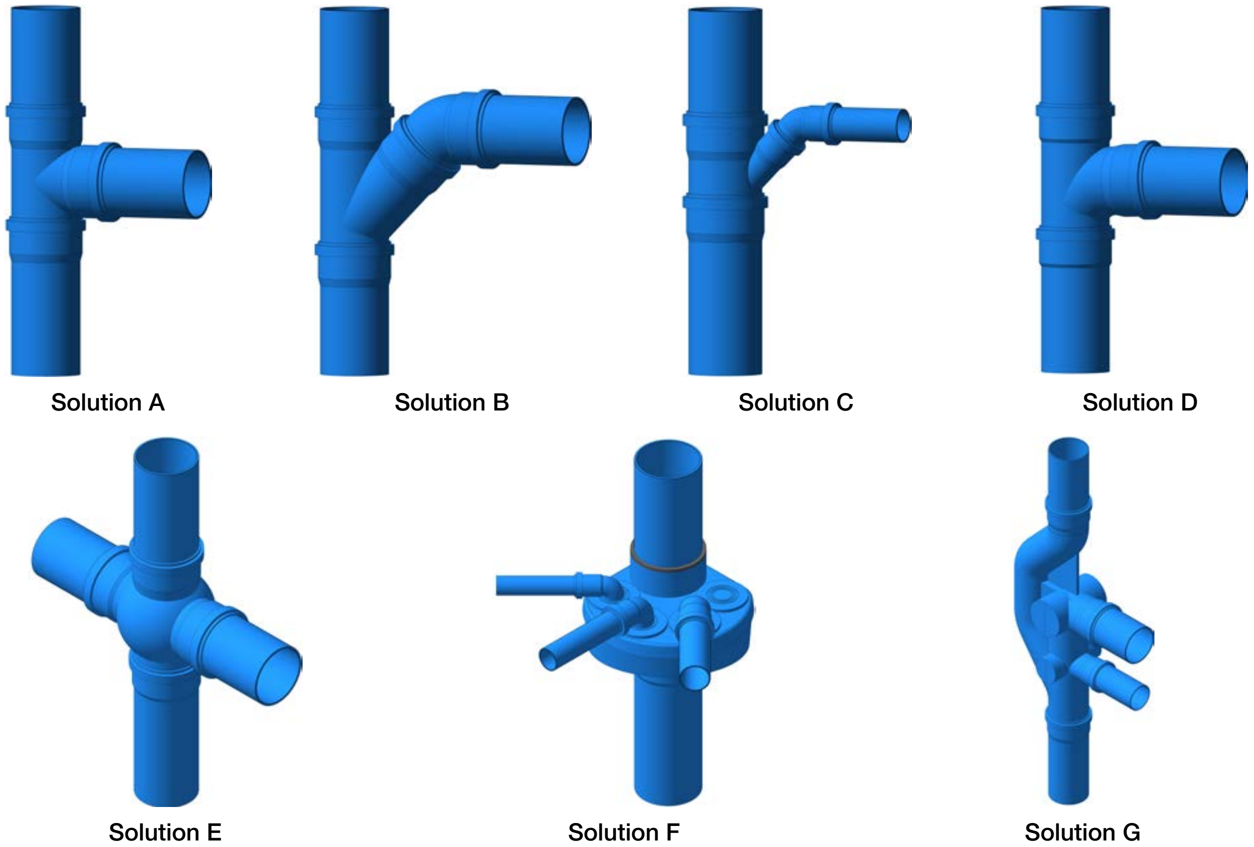
Figure 3.40 Deceleration by means of stack deviation.



3.5.3 Connections to the stacks

The type of connection chosen for stack branches affects not only the drain flows, but also the system noise. The connection to the stack can be made using various solutions and the choice must be made considering the following aspects.

Figure 3.41 Stack connection types.



Solution A The square branch fitting, featuring connection angles between 87° and 88.5°, is a solution that facilitates air circulation, keeps the flow speed low and allows low noise levels.

Solution B The angle branch fitting, featuring angles smaller than the square branch fitting (e.g. 45°), even it generates higher drain flows (approx. 30% higher), it is not recommended as it reduces air circulation and raises noise levels. In fact, the flow is accelerated by hitting the vertical walls of the stack in the inlet area. In addition, this solution is more expensive than the previous one as it requires a 45° bend.

Solution C The reduced insertion branch fitting is a solution adopted when the horizontal branch flow is limited and, therefore, its diameter is reduced compared to that of the waste stack. It can be made with square branch fitting or angle branch fitting (see solution A and B). It is important that the branch is not overloaded to avoid self-siphonage problems; in case of angle branch fittings, where the flow is accelerated in the oblique section, there may be a noise increase due to the flow impact against the stack walls.

Solution D The curved or swept branch fitting combines the benefits of the square branch fitting and the angle branch fitting. It allows to increase drain flows while maintaining optimum air circulation, so there are no siphonage problems that may reduce the level of the hydraulic seal of the siphons and thus create noise. In addition, the noise level is limited as the impacts generated by the introduction of water into the stack are reduced thanks to the branch fitting profile that facilitates input into the stack.

Solution E The ball branch fitting allows to have from 2 to 4 inlets each fitting, facilitating design and installation choices. Thanks to its geometry, it allows to increase the volume in the stack inlet area, resulting in several benefits. First of all, the flow coming from the horizontal inlets occupies only a small part of the space available in the stack inlet area and is distributed on the perimeter of the fitting, leaving the central part of the waste stack free; this facilitates air circulation both in the branches and between the various levels of the system, reducing noise and increasing drainage capacity. In addition, at each floor where the ball branch fitting is installed, the flow coming down from the upper levels finds a break in the continuity of the pipe wall; this slows its fall reducing its speed and, as a result, the noise generated by.

Solution F Multibranch is a special fitting that allows conveying the various discharges of a bathroom or a kitchen independently, directly to the waste stack. There are 4 inlets where, thanks to the seal flexibility, it is possible to connect pipes with diameter from 32 mm to 50 mm. This type of fitting allows to connect the various sanitary fixtures directly to the waste stack, as provided for system III of standard EN 12056, also facilitating the implementation of horizontal branches at a later time than the waste stack. It is not possible to connect pipes coming from the WC to this fitting; in this case a Multibranch must be coupled with one of the above mentioned solutions A, B or D.

Solution G The VBF branch fitting is a waste system that allows drainage for very high buildings or with high drain flows into a single waste stack with smaller diameter, without the need of additional ventilation stacks. This thanks to its excellent capacity of managing ventilation from inside the waste stack and in the horizontal branches. The reduction of the pipes diameter and quantity, and fewer stacks, allows cost and space savings.

3.5.4 Configuration of the stack base

The stack foot is the point where the waste flow undergoes a sudden change of direction from the stack to the collector. Overpressure and high noise levels can generate in it if not properly configured. The stack foot can be made in different ways, with a 90° bend, a radial 90° bend or two 45° bends; it can be embedded in the concrete or cross the slab without contact with it. In any case there are recommended and not recommended solutions.

Figure 3.42 Different solutions for stack base not laid in concrete.

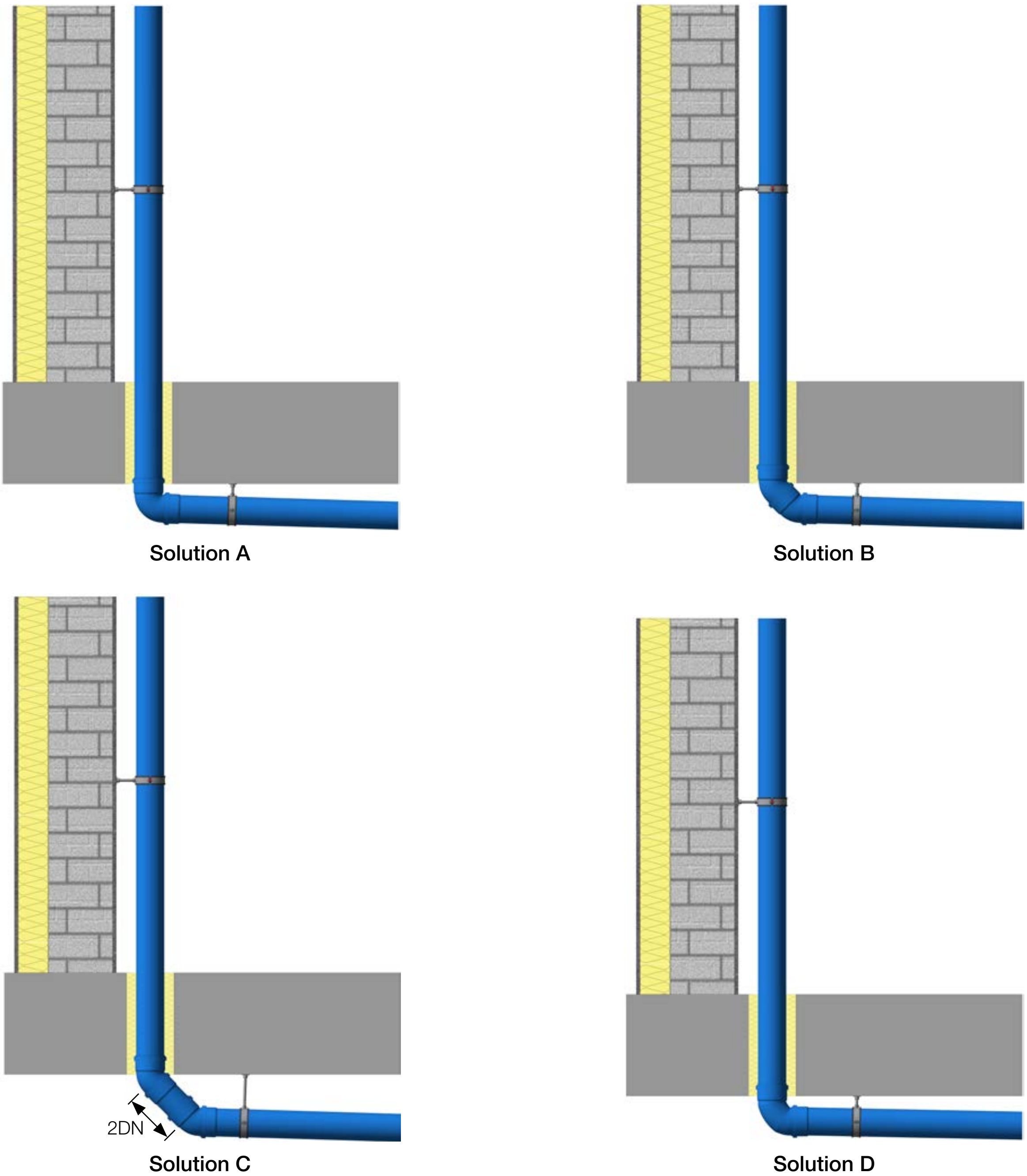
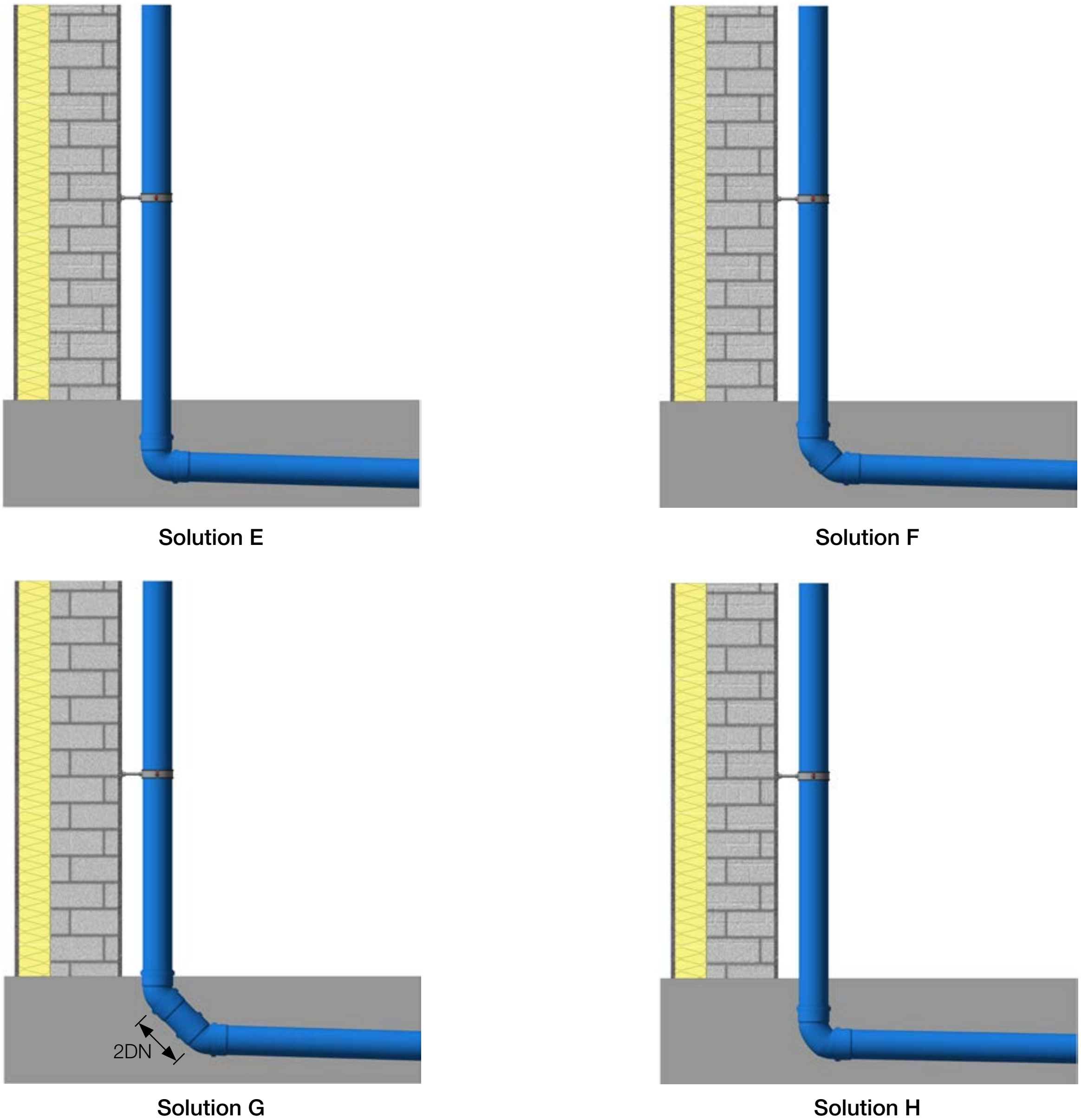


Figure 3.43 Different solutions for stack foot laid in concrete.



Solution A The solution with 90° bend should be avoided as the pressure generated and the noise level reach the highest values. This solution, technically very simple, involves high siphonage risks.

Solution B The offset is made with two 45° bends installed consecutively; this solution reduces both overpressure and noise levels, but should be preferred to solution C only when there are space problems.

Solution C This is the most suitable configuration. It is made by placing a section of pipe with a length that is two times the nominal diameter of the stack, between the two 45° bends. This solution greatly reduces the pressure overloads and it is characterised by noise levels that are lower than solution A, by at least 30%.

Solution D Compared to solution A, the solution with radial 90° bend facilitates change of direction thanks to the rounded profile. It is halfway between solution A and solution B both for noise and overpressure damping; it uses a single fitting and allows to reduce the overall dimensions compared to the double 45° bend. This is a solution that can be used, even if solutions B and C are preferable.

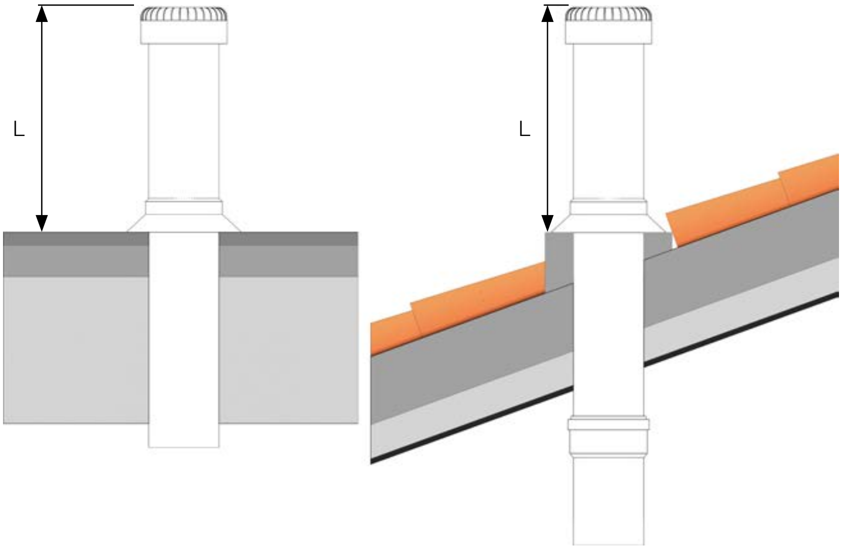
Solutions E,F,G,H The difference between these configurations is that the stack foot is fully embedded in the concrete. Obviously, pressure levels inside the stack do not change compared to the cases described above, while the noise level is significantly reduced thanks to the damping effect of the concrete (high mass). Noise in these configurations is reduced by approx. 70÷80% compared to the previous ones, solution F reaches, therefore, noise levels 80÷90% lower than those of solution A.

3.5.5 Configuration of the stack relief vent

Ventilation stacks terminate beyond the roof through ventilation terminals (aerators) configured in order to prevent rainwater from entering the stack and facilitate the entry of air. The aeration terminal must have a distance L from the roof of min. 30 cm; in snowy areas, this distance must be properly increased.

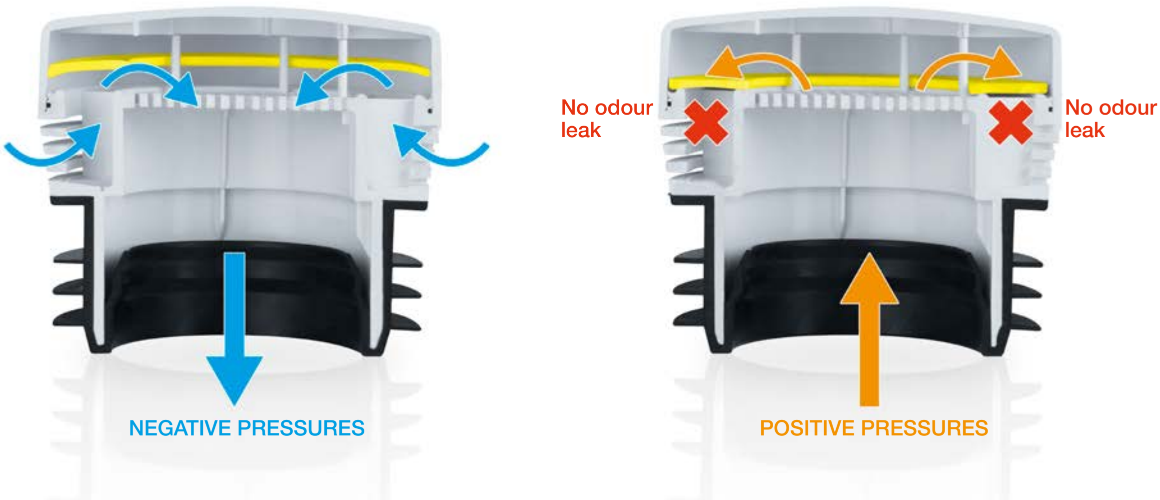
Figure 3.44 Ventilation terminal.

Figure 3.45 Installation of the terminal on the roof.



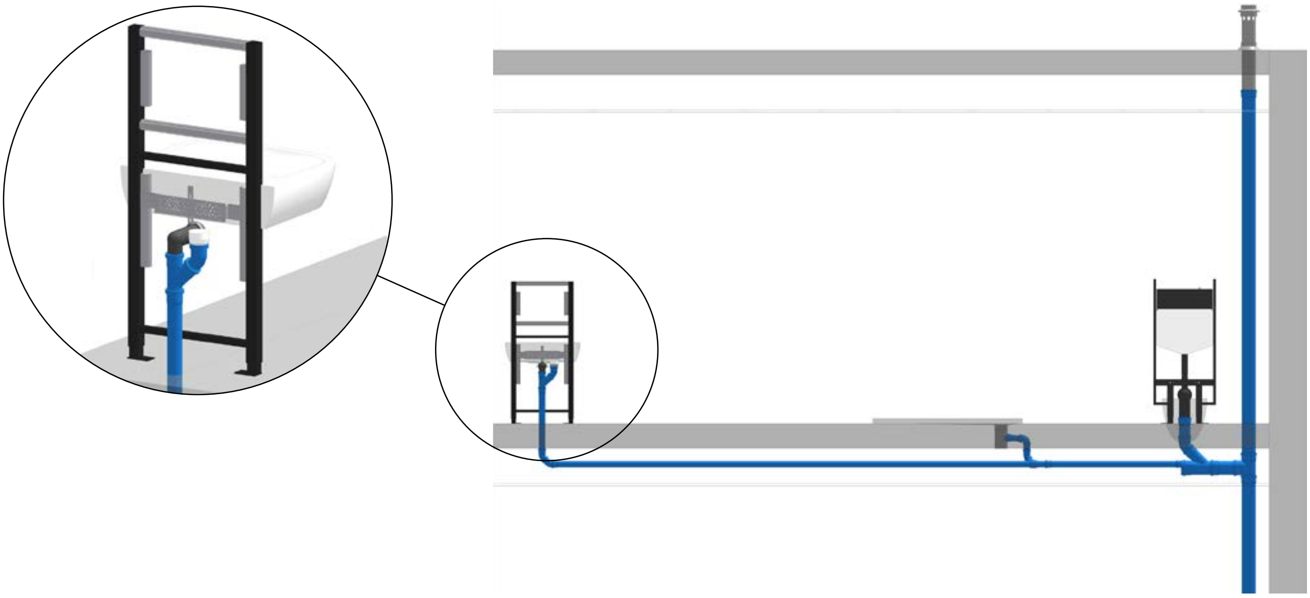
There may be cases where the ventilation pipe cannot cross the roof, due to structural problems or habitable roofs. In these cases it is possible to replace the ventilation terminal on the roof with an air admittance valve. This component contains a membrane that allows air to enter in the waste system, if a vacuum situation occurs inside it. However, if overpressure generates inside the system this membrane prevents the exit of malodorous air from the inside of the system. These components are often used as an integration in old systems where the ventilation system is insufficient or missing. The aerator with membrane allows to improve the system operation without the need to move the pipe outside the building.

Figure 3.46 Aeration valve.



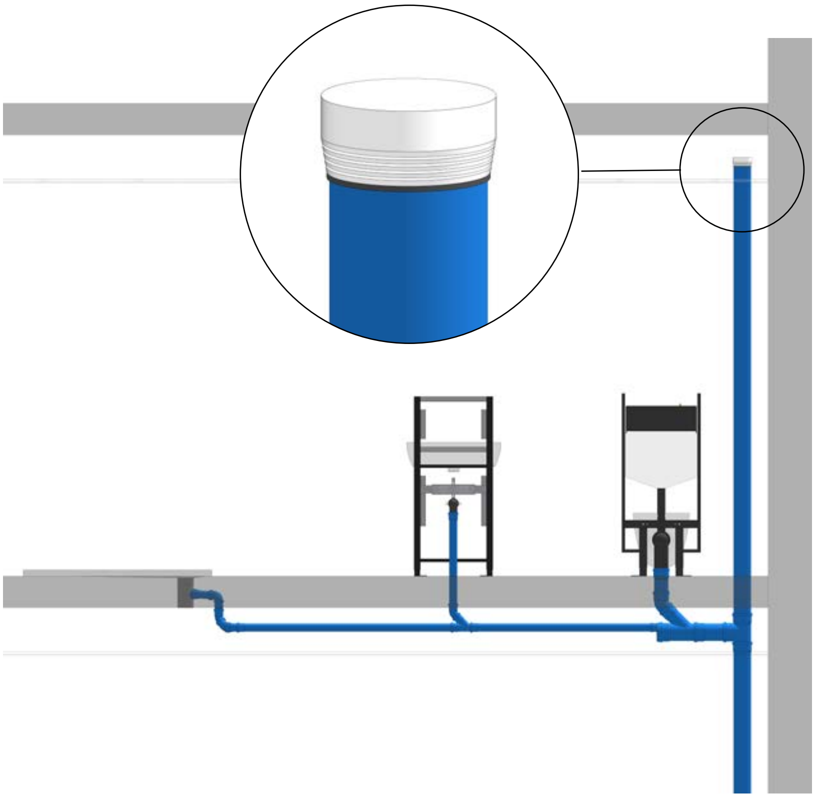
There are two different sizes of air admittance valves available, which differ in the diameter of the pipe they can connect to and the air flow rate they can provide.
The model with reduced overall dimensions can be connected to pipes with external diameter of 32, 40, 50 and 63 mm, has an air flow rate of 6.1 l/s and is typically used for ventilation of a single sanitary fixtures or small waste branches.

Figure 3.47 Example of ventilation of a waste branch through air admittance valve.



The other model can be connected to pipes with external diameter of 70, 75, 90, 100 and 110 mm and it has an air flow rate of 23.2 l/s and is typically used for the ventilation of waste stacks.

Figure 3.48 Example of ventilation of a waste stack through air admittance valve.



For sizing of ventilation sections with these air admittance valves, see chapters 4.3.3 and 4.4.3.

3.6 Waste collectors

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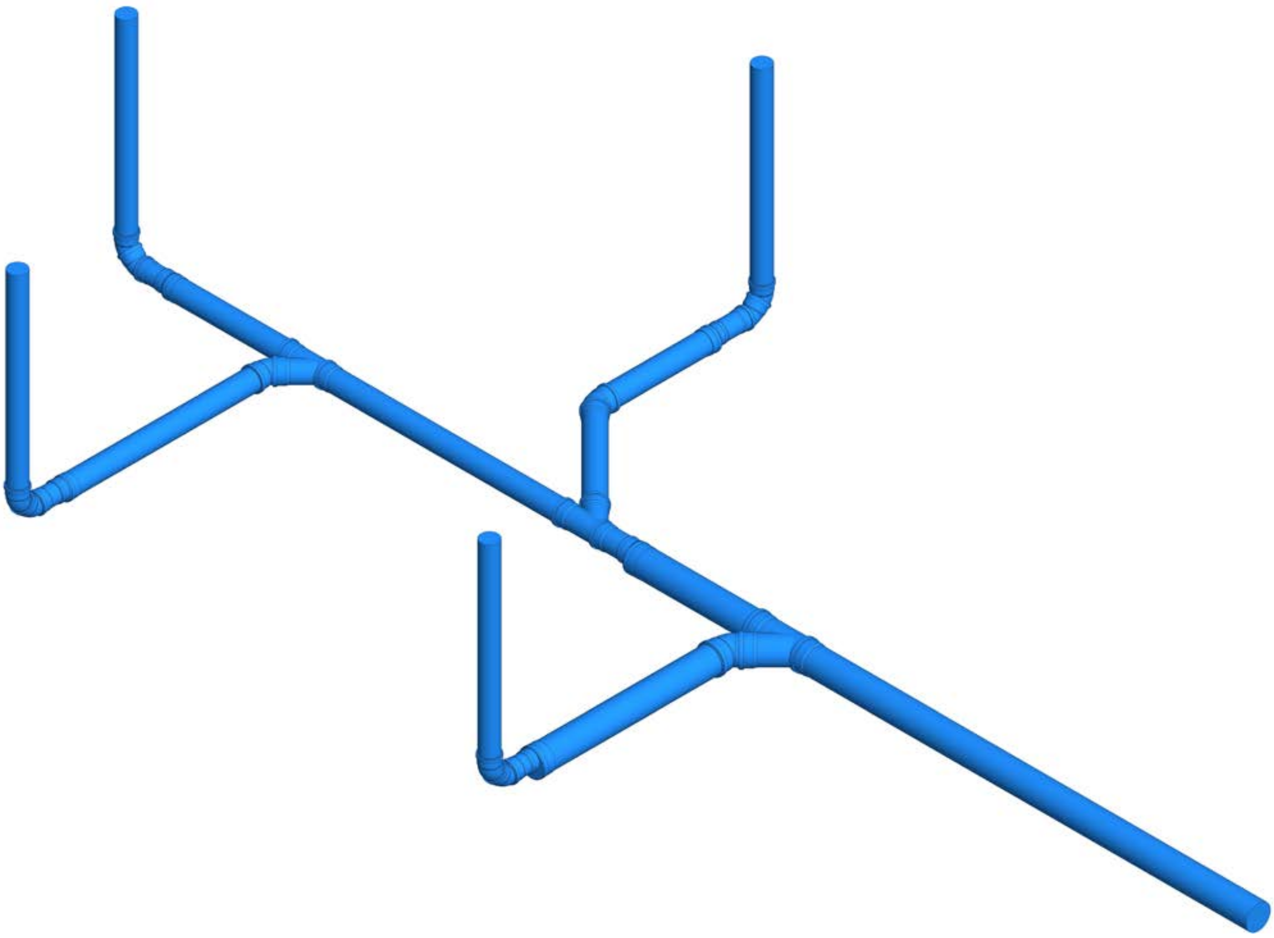
The waste collectors are made up of horizontal pipes that are surface-mounted inside the building (for example, on the ceiling of the garage) or underground to which the waste stacks are connected and possibly the sanitary fixtures on the ground floor.
In designing the waste collectors, besides observing the requirements set by UNI EN 12056 and dealt with in the chapter on waste system sizing, also the following aspects should not be overlooked:

- The waste collector configuration must be chosen according to the building structure and taking into consideration any architectural obstacles.
- If the conduits cross structural parts of the building, it is recommended to make a hole that is larger than the diameter of the conduit to avoid the natural movements of the ground caused by the weight of the building having a negative effect on or damaging the conduits. Pipes made of plastic are, in fact, ideal in these conditions thanks to their excellent elasticity.
- The pipes that make up the collector must be as straight as possible and the bends must be made with a wide radius and avoiding 90° angles.
- The flow must ensure a minimum speed of 0.6 m/s to prevent the formation of deposits; slope values must always be decided considering these aspects.
- Gradient values must be between 1% and 5%; the ideal gradient is considered to be 2%.
- The diameter of the collector must be no smaller than the diameter of the biggest section of the stack that leads into it.
- The passage toward greater diameters must be made by employing eccentric reducers keeping the upper part of the pipes straight.

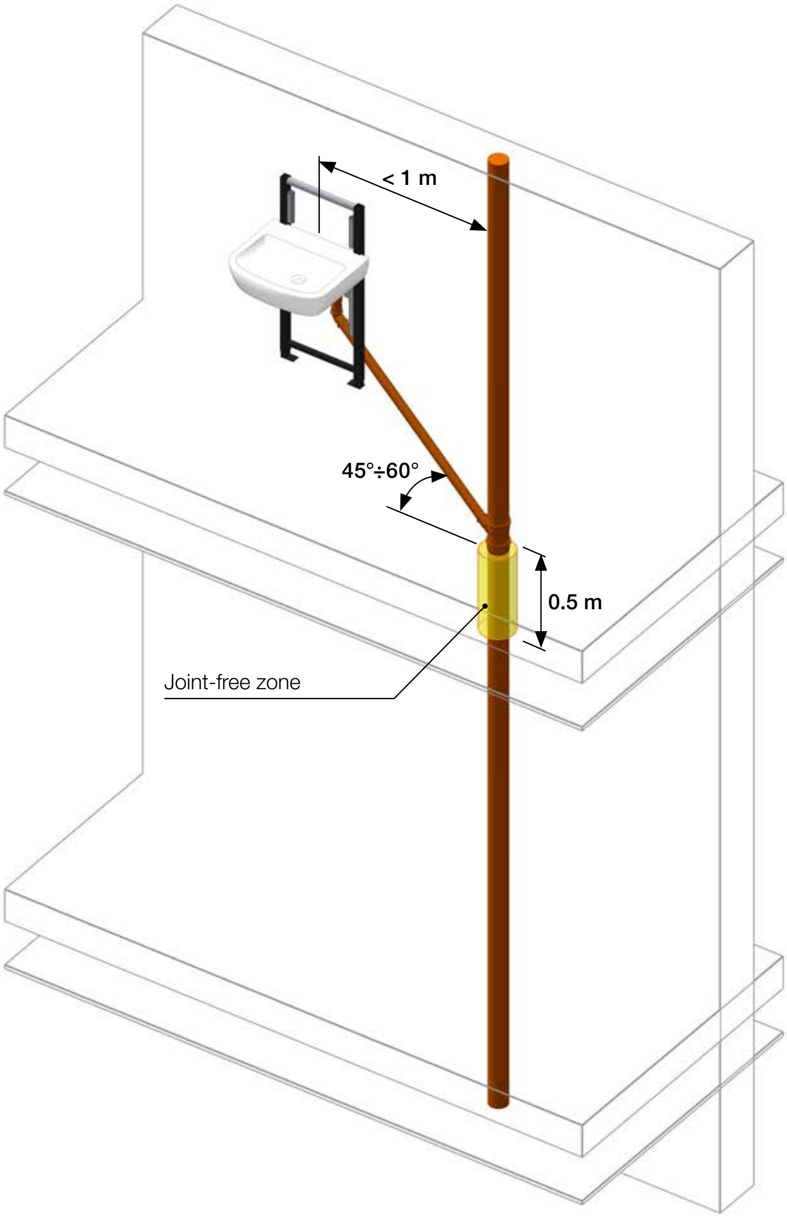
Figure 3.49 Waste collector.



3.7 General rules for connections

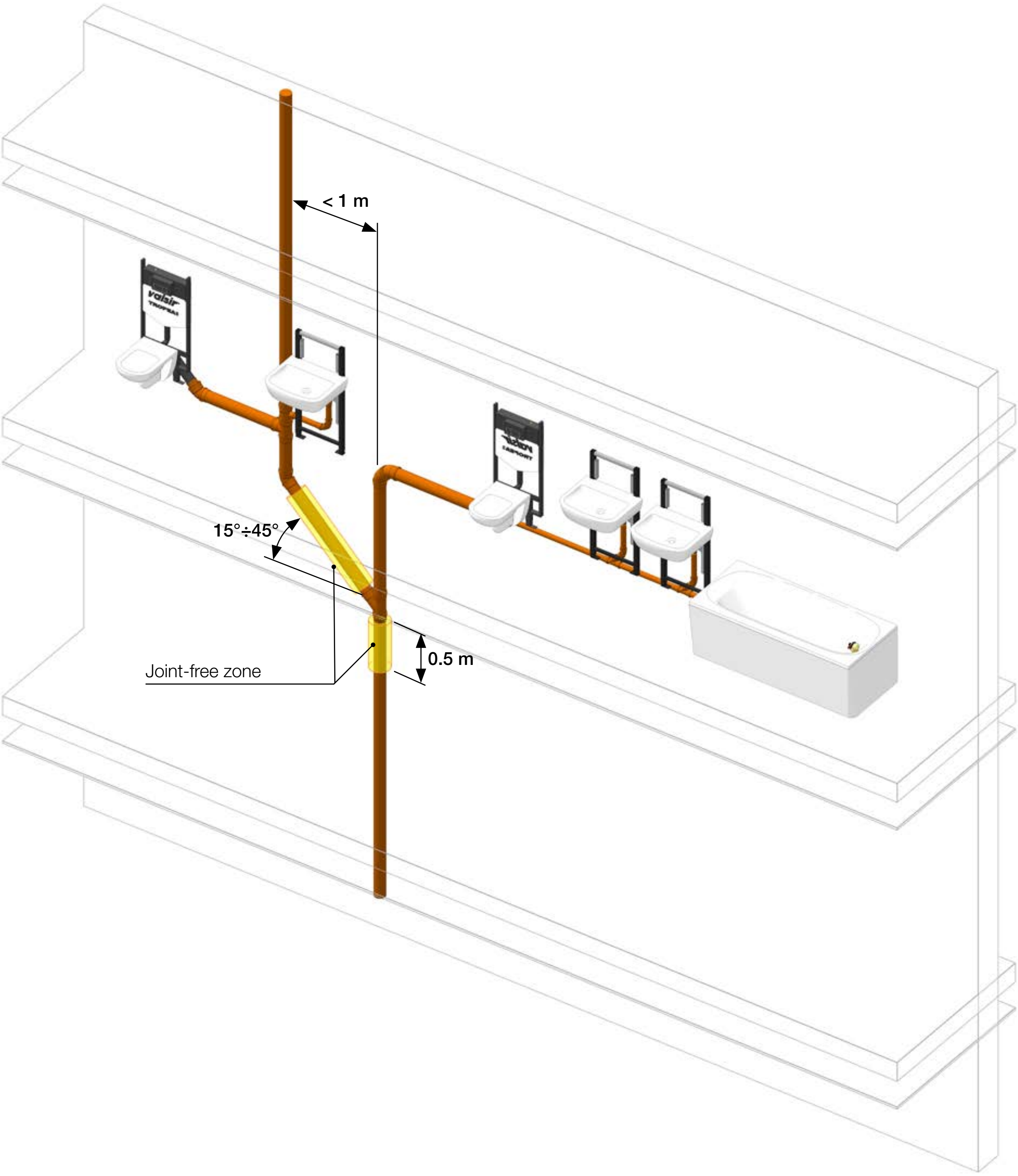
Some general rules should be observed when creating connections within waste systems, for example, when connecting branch pipes to waste stacks or waste stacks to waste collector pipes.
A fixture can be connected directly to a waste stack with a sloping tract of 45°, or 60°, as long as the distance between the fixture and the waste stack does not exceed 1 m and after the connection there are no other joints for at least 0.5 m.

Figure 3.50 Direct connection of sloping branch to waste stack.



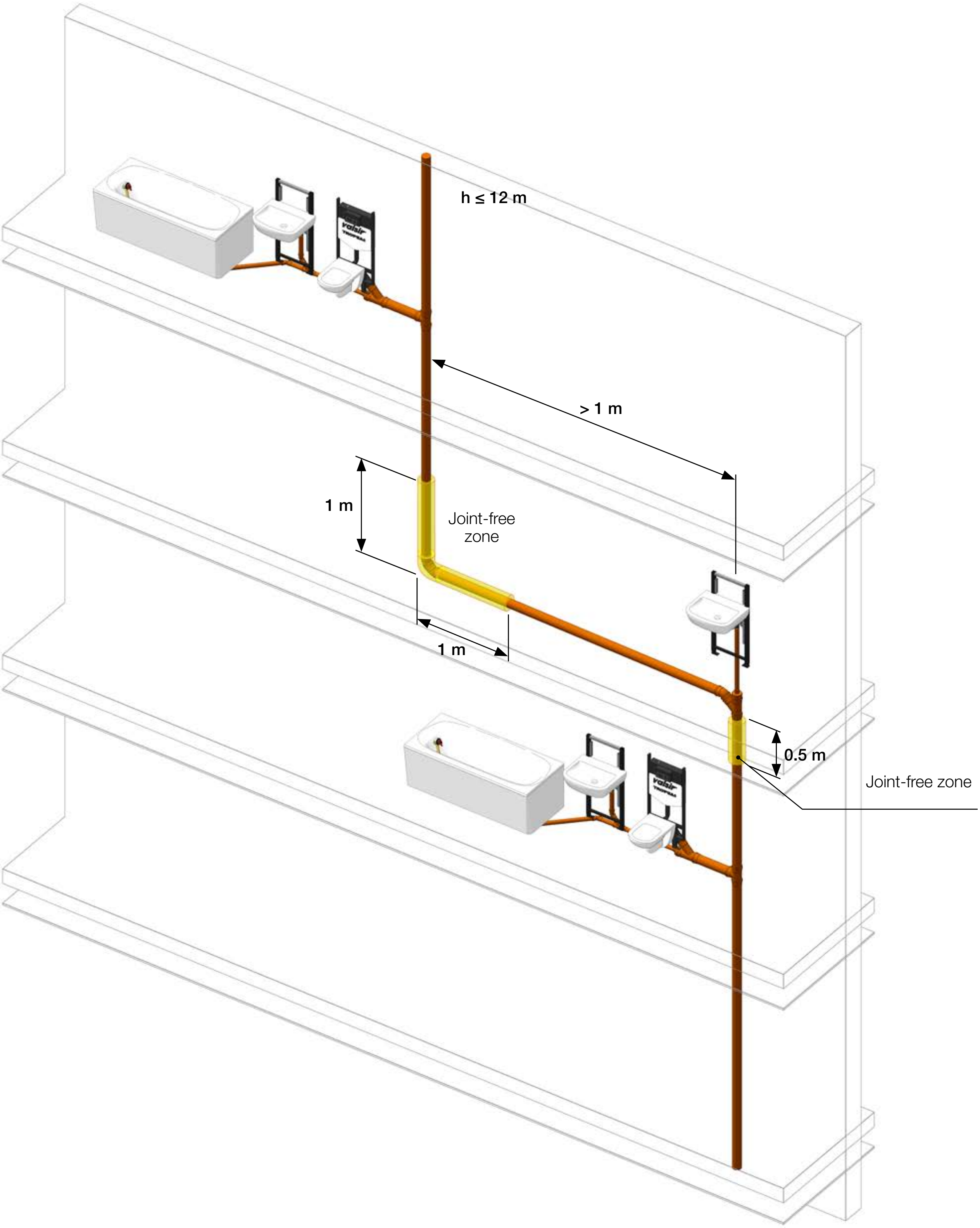
If inclined sections (15°, 30° or 45°) are used as stack offsets, must not exceed 1 m and it is necessary to check that there are no further connections for at least 0.5 m after the connection.

Figure 3.51 Connection near stack offset.



Near stack offsets greater than 1 m (constructed with horizontal tracts), such as, for example, the stack base, connections are to be avoided in the zones indicated in the following illustrations. The extension of such zones depends on the height of the stack, or the number of floors of the building.
For stacks that drain up to 5 floors where the distance between the highest drainage point and lowest drainage point is h ≤ 12 m, the joint free zones are 1 m above and 1 m below the stack and 0.5 m below return into the stack.

Figure 3.52 Connections near stack offsets greater than 1 m in stacks that drain up to 5 floors (h ≤ 12 m).



For stacks that drain over 5 floors where the distance between the highest drainage point and the lowest drainage point is h > 12 m, the joint-free zones are 2 m above and below the stack base and 0.5 m below return into the stack.

Figure 3.53 Connection near stack offsets greater than 1 m in stacks that drain over 5 floors (h > 12 m) - Case 1.

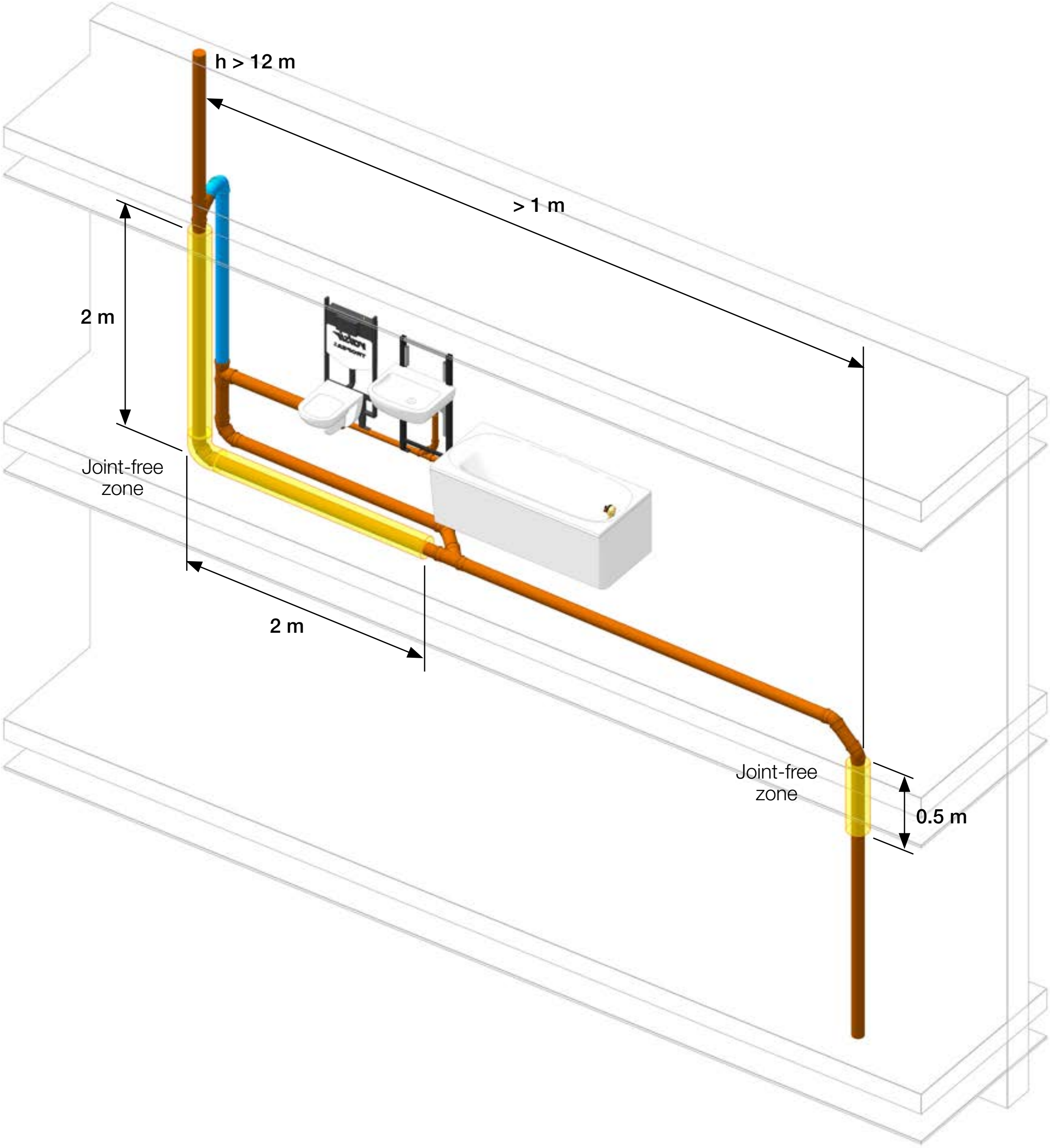
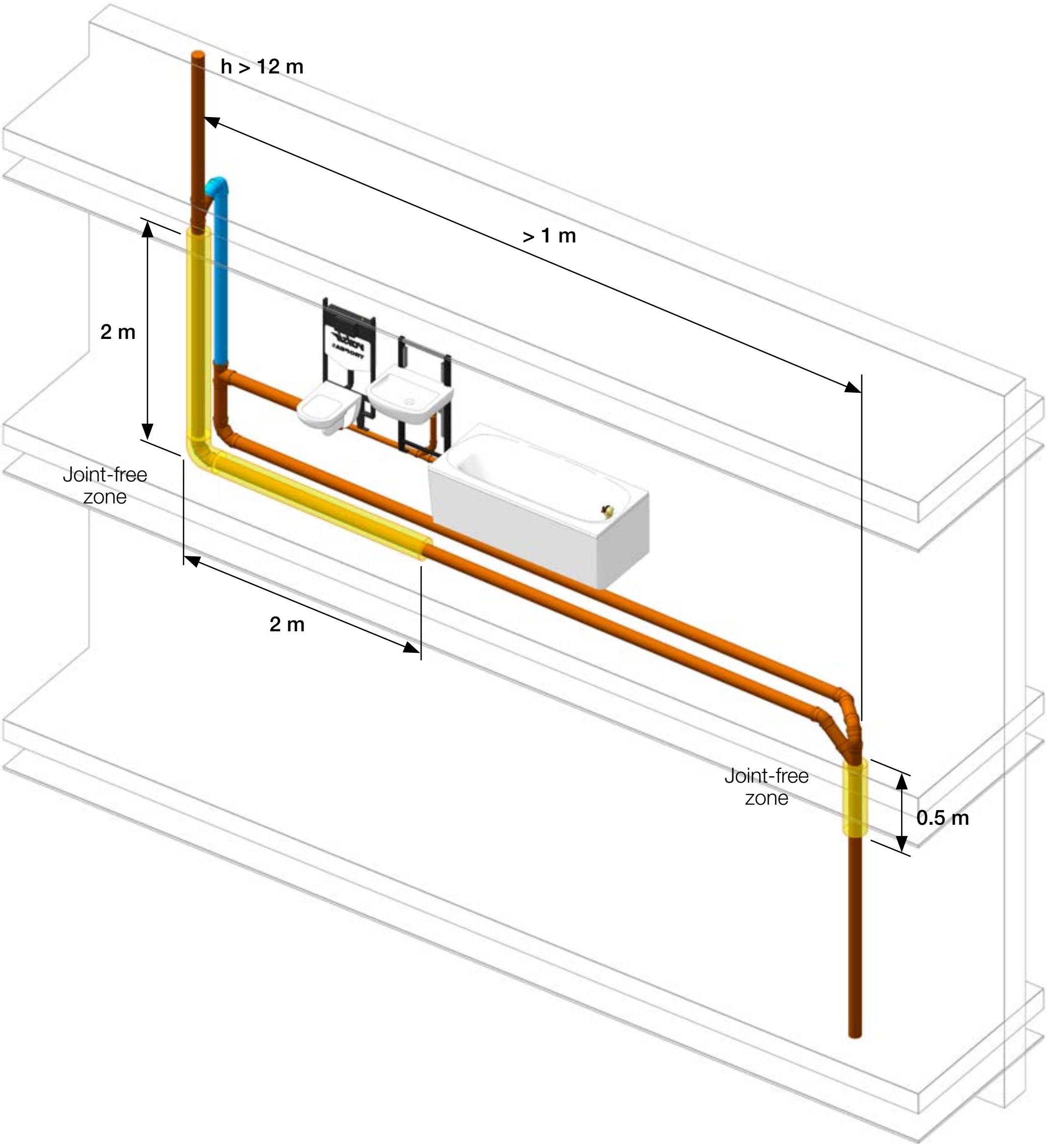


Figure 3.54 Connection near stack offset greater than 1 m in stacks that drain over 5 floors (h > 12 m) - Case 2.



3.8 Inspections

In order to flush and clean the waste network, it is necessary to provide suitable access fittings positioned in areas that are easily accessible. The opening of the access fitting must be suitably sized and in any case, it cannot be smaller than the waste pipe diameter and the space surrounding the fitting must guarantee ease of use of the instruments necessary in cleaning operations.

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Figure 3.55 Inspection junctions.

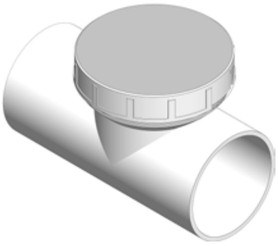
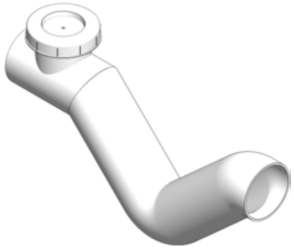


Figure 3.56 Inspection trap (Firenze trap).



The inspection junctions must be installed in the following positions:

- At each change of direction with angles greater than 45° (Figure 3.58).
- At the base of every stack (Figure 3.57 and Figure 3.58).
- At every confluence of more ducts (Figure 3.58).
- On linear ducts, every 15 m for pipes up to DN 100 and every 30 m for pipes over DN 100.
- At the end of the internal waste system by means of an inspection trap (Figure 3.56 and Figure 3.58).

Figure 3.57 Inspection types for stack feet.

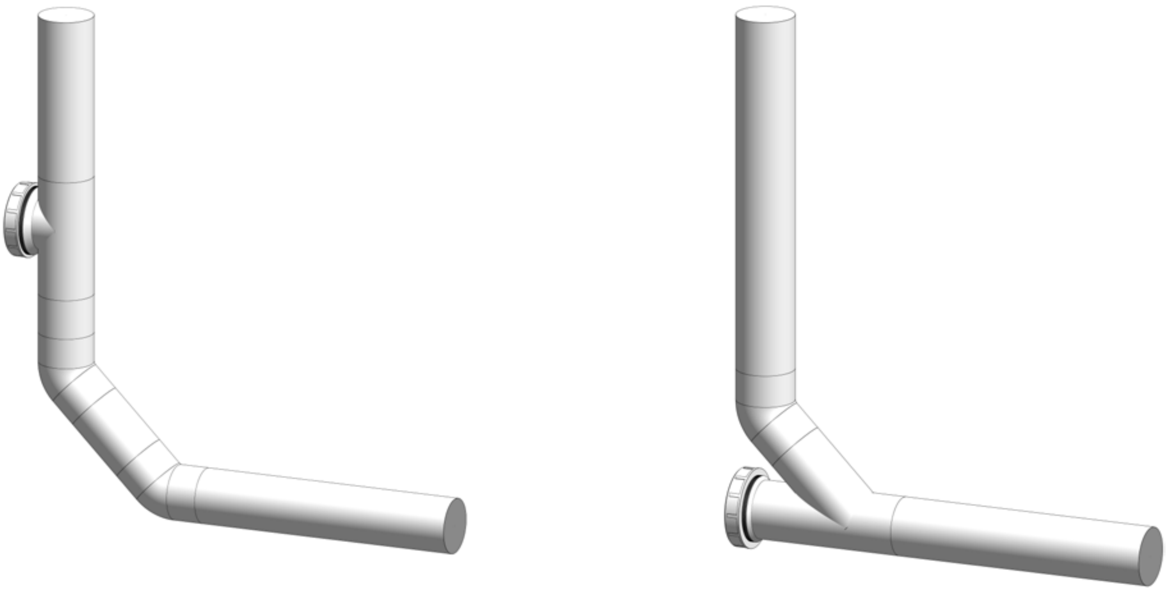


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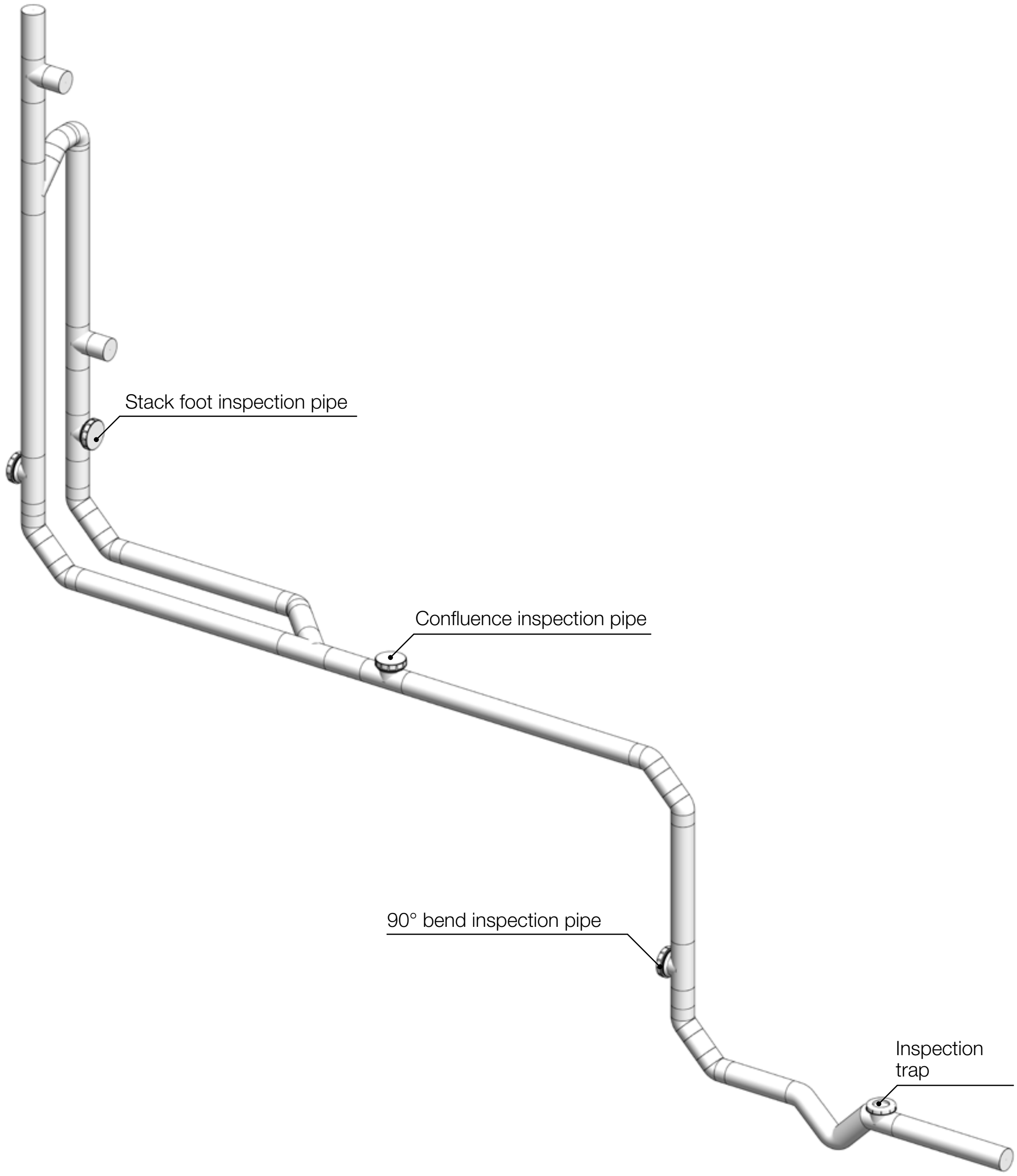
Figure 3.58 Positioning of the access fittings.



3

WASTE SYSTEMS

SUPPLY SYSTEMS

GAS SYSTEMS

FLUSHING SYSTEMS

BATHROOM SYSTEMS

TRAPS

RADIANT SYSTEMS

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HRV SYSTEM

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VALSIR S.p.A. - Società a Socio Unico
Località Merlaro, 2
25078 Vestone (BS) - Italy
Tel. +39 0365 877.011
Fax +39 0365 81.268
e-mail: valsir@valsir.it

www.valsir.it

Soggetta all'attività di direzione e coordinamento ex art. 2497 bis C.C.
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