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Pit Latrine Ventilation: Design Concepts

Context

The performance of pit latrine ventilation is often found to be a problem in the field. The presence of bad smells inside the latrine and/or the presence of flies significantly impacts the experience and overall comfort of users, which can lead to avoidance of the latrine as well as neglect of the basic maintenance. Good ventilation is all about the air being sucked through the slab opening into the pit and through the vent pipe (see Figure 1), keeping the smell and the flies out of the toilet cabin. **This guidance document is aimed towards all WASH stakeholders involved in design and implementation of pit latrines, in order to facilitate the review of detailed designs, monitoring before commissioning and maintenance of the sanitation facilities.** It also supports the identification of design, implementation or maintenance issues when the ventilation is found not to work properly, and the respective potential mitigation/retrofitting measures.

The document summarises the key design features of a pit latrine ventilation, along the following sections:

1. Design of the vent pipe
2. Fly screen
3. Design of ventilation openings in the structure
4. Options for closing the squat hole
5. Maintenance

Summary - key design concepts:

- *Good ventilation is all about the air being sucked through the slab opening into the pit and through the vent pipe.*
- *The superstructure should be kept reasonably dark to deter flies, but there should be a gap, usually above the door, to allow air to enter and for sufficient light for users.*
- *Venting velocities increase substantially when the toilet superstructure opening faces the prevailing wind.*
- *It is important to avoid openings on opposite sides.*
- *The ventilation openings should preferably be screened*
- *The vent pipe should extend at least 30 cm above the highest point of a sloping roof.*
- *Vent pipes should be straight to ensure entry of light into the pit to attract the flies.*
- *The vent pipe should preferably be located on the outside of the superstructure.*
- *The flyscreen and the vent pipe should be regularly inspected to ensure that they are in good condition. There is a danger that cobwebs, dirt or insect matter may build up on the screen and restrict the air flow.*
- *When a lid is used to close the squat hole, it should be regularly disinfected, especially the handle.*

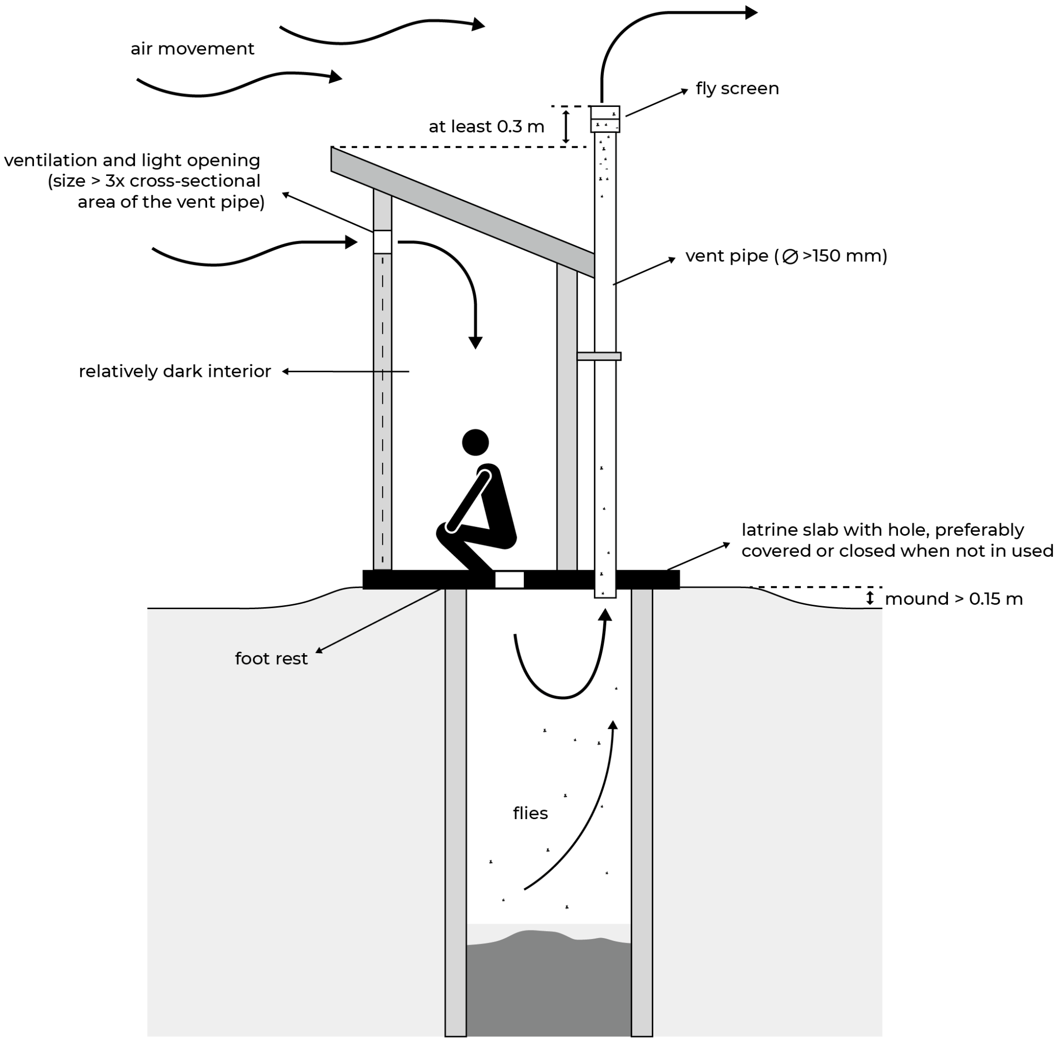

Figure 1: Design basics of pit latrine ventilation (adapted from Harvey, 2007)

1. Design of the vent pipe

A vent pipe covered by a fly screen, combined with a relatively dark interior to the superstructure, will:

- reduce faecal odours in the superstructure
- prevent most flies from entering the pit and thus reduce the amount of flies breeding in the pit
- prevent flies which have managed to breed in the pit from escaping.

The vent pipe should extend **at least 30 cm** above the highest point of a sloping roof. It **should not protrude into the pit**. The slab can be cast with a piece of wire across the vent pipe hole to prevent the pipe sliding down into the pit.

The vent pipe should be designed so that it can induce sufficient air flow through the toilet to leave the superstructure odour free. **Under-design** of the vent pipe will normally cause problems in odour and insect control, while **over-design** will increase costs unnecessarily.

It is recommended to **close the squat hole when not in use** (see Section 4). Otherwise, uninterrupted ventilation by means of air flow down the squat hole and up through the vent pipe should be maintained. There are two possible mechanisms for maintaining the circulation of air through the toilet system: the suction effect of wind across the top of the vent pipe and the thermal effect of solar radiation on the vent pipe's external surface. The two most important factors governing the ventilation rate are the **local wind speed and its direction**.

The direction of the wind relative to openings (doors, windows) in the superstructure has a major influence on the ventilation efficiency. Venting velocities increase substantially when the toilet superstructure opening **faces into the wind**. Fixing cowls (see Figure 2) should not be used, as they reduce the wind shear at the top of the vent pipe by inducing turbulence. Rain cowls also reduce the air flow through the vent pipe and the amount of rain entering the pit is not likely to be significant, but rather beneficial for the processes in the pit.

Testing the ventilation performance

A "smoke test" with closed door (i.e. blowing smoke towards the slab opening) can provide a good indication of how the air flows in the structure.

Vent pipes should be straight to ensure entry of light into the pit to attract the flies. A straight pipe also maximizes the air flow, whereas bends in the vent absorb part of the energy in the air movement. In case of bent pipe (not recommended), where the pipe goes out of the pit horizontally before turning vertical, an ancillary light source is required in the form of a small glass window at the bend, as illustrated in Figure 3.

Figure 2: A fixing cowl – to be avoided for optimal ventilation

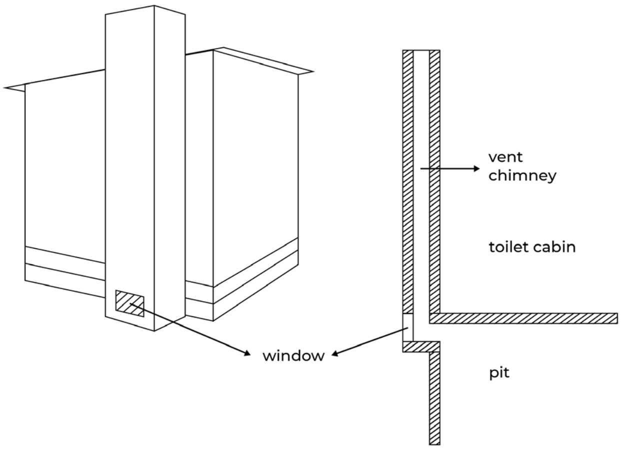

Figure 3: Installation of a small window at the bend of the vent pipe to attract flies into the pipe

The vent pipe should **preferably be located on the outside of the superstructure**, since it is more difficult and expensive to ensure a rainproof and wind-tight seal between the roof and a vent pipe going through it. However, external vent pipes could be subject to damage by vandals, and so a trade-off should be found on a case-by-case basis (for example, construction out of bricks). The vent pipe should be rigidly fixed to the superstructure and the cover slab. Figure 4 illustrates a design commonly used in Zimbabwe (Blair latrine).

A **wide variety of different materials** have been successfully used to form vent pipes, e.g.: polyvinyl chloride (PVC); unplasticized PVC (uPVC); bricks; or bamboo with the cell dividers removed. Important factors in the choice of material are its durability, availability, cost and ease of fixing it in place. Brick vent pipes have the advantage that they retain heat longer than PVC pipes and can thus maintain a thermally induced circulation of air well into the night. Thin galvanized steel sheets are not recommended as they are prone to corrosion. PVC pipes become brittle when exposed to high sunlight intensities; it is thus better to use PVC pipe made with a special stabilizer to prevent damage by ultraviolet radiation.

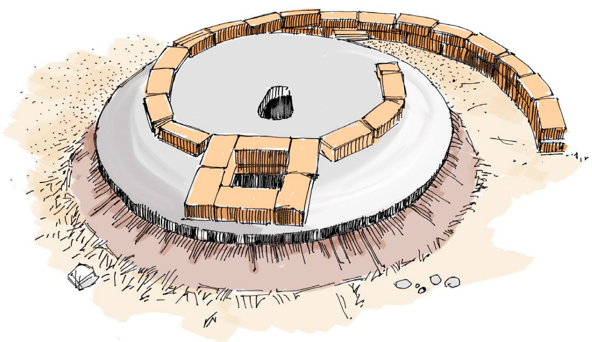

Figure 4: Basis of a brick ventilation chimney in a Blair VIP latrine design (source: WEDC, 2014)

The following minimum vent pipe sizes are recommended for various applications (Table 1). Circular vent pipes should normally have an internal diameter of at least 150 mm for smooth materials or 230 mm for rough surfaces (such as locally produced cement-rendered pipes), although in exposed places with high wind speeds a smaller diameter may be sufficient. Vent pipes may be made from bricks with cement mortar joints in the form of a chimney that is at least 225 mm^2 internally.

Table 1: Recommended minimum internal size for various pipe material (source: Ryan & Mara, 1983)

	PVC	Brick	Cement
Permanent installations, mean wind speed below 3 m/s (design venting capacity 20 m^3/h)	150 mm diameter	230 mm square	250 mm diameter
Permanent installations, mean wind speed above 3 m/s (design venting capacity 20 m^3/h)	100 mm diameter	180 mm square	200 mm diameter
Rural installations, minimum cost urban installations	100 mm diameter	190 mm square	200 mm diameter

Figure 5: Vent pipes out of bricks and PVC in a school in Tongogara Refugee Camp, Zimbabwe.

2. Fly screen

By covering the top of the vent pipe with a fly screen, flies are prevented from entering the pit through the vent pipe and those which enter via the squat hole are trapped inside and will eventually die. The fly screen should be made from **corrosion resistant material**. Glass-fibre reinforced plastic mesh with 1 mm x 1 mm openings has been found to be ideal. A mesh size of 1.2 mm x 1.5 mm can also be used. If the apertures are larger small flies can pass through. If the apertures are smaller there is too much resistance to the updraught of air. Plastic fly screens are weakened by ultraviolet light and galvanized steel corrodes quickly.

3. Design of ventilation openings in the superstructure

The superstructure should be kept reasonably dark to deter flies, but there should be a gap, usually above the door, to allow air to enter and for sufficient light for users. The ventilation openings should preferably be screened and should be left at the top of the walls or between the top of the door and the roof. The minimum size of the ventilation opening(s) should be at least three times the cross-sectional area of the vent pipe.

Inlet vents are **most effective when they face the prevailing wind** and should preferably be at a different height from the outlet in order to improve the efficiency of air exchange. However, where the prevailing wind is variable, it may be necessary to have other openings in the structure to prevent a suction effect when the wind blows from a different direction. Such a suction effect can lead to back-ventilation. It is extremely important to **avoid openings on opposite sides**, as this would significantly reduce the pressure difference which causes updraught in the vent pipes.

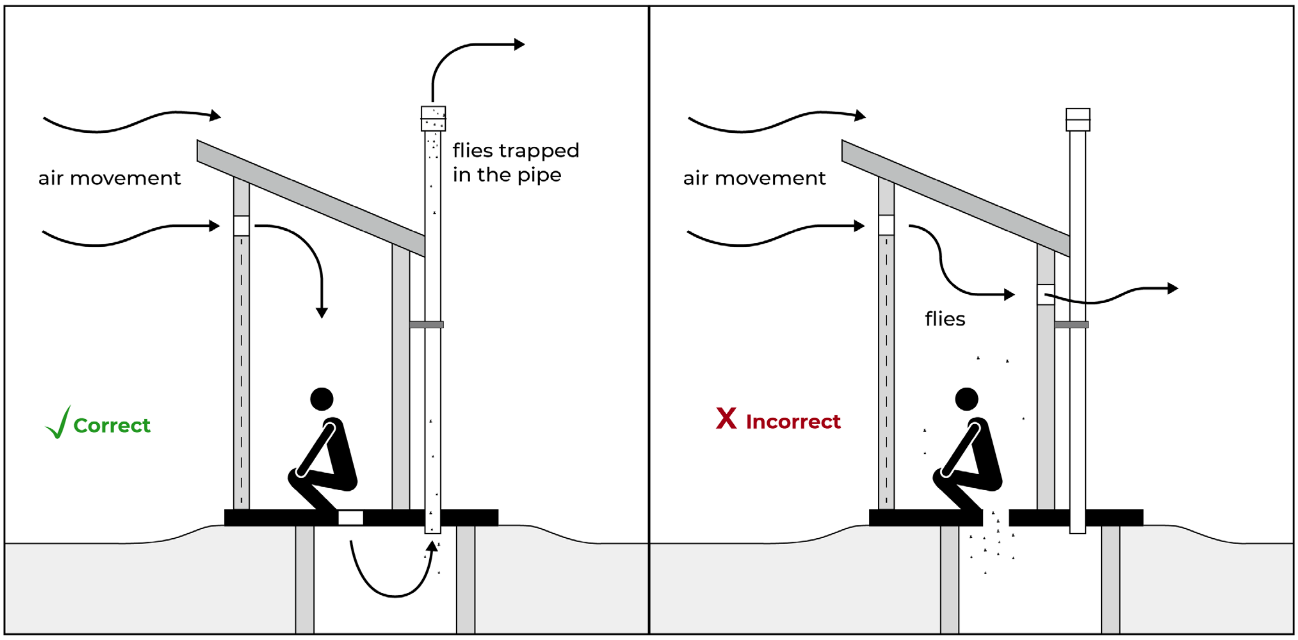

Figure 6: Best practice for ventilations openings (left); on the right, the opening in the back of the toilet prevents the air to flow through the drop hole and the ventilation pipe, resulting in smells and flies in the cabin
(source: WEDC, 2014)

4. Options for closing the squat hole

Another way to reduce smell and flies is to keep the squat hole closed while not in use. This can be done through the use of a lid with handle that can be moved easily (for example to close the hole of a SanPlat, as shown in Figure 8), or through a self-closing mechanism embedded within the slab, such as SaTo pan (Figure 7 - see also UNHCR, 2016). In this latter case, the mechanism only opens when urine or faeces apply pressure at its surface. It should then be cleaned with a minimal amount of water.

Figure 7: SaTo pan closing mechanism, and its integration into SanPlat.
(source: engineeringforchange.org)

Figure 8: SanPlat with movable lid, Zambia

5. Maintenance

The following maintenance activities should be regularly carried out:

- The flyscreen, the vent pipe, the vent pipe opening in the slab, and the cover slab should be regularly inspected to ensure that they are in good condition. Any gaps and cracks should be repaired. The flyscreen should be inspected each year and replaced if damaged.
- There is a danger that cobwebs, dirt or insect matter may build up on the screen and restrict the airflow. Once each month, a minimal amount of water should be poured down the vent pipe to get rid of spider webs.
- When a lid is used to close the squat hole, it should be regularly disinfected, especially the handle.

Case studies: design issues observed on the field

The ventilation pipes are below the roof - ventilation pipes should reach at least 30 cm above the roof.

The ventilation pipe has one or two bends, preventing the flies to see directly the sunlight in the pipe. The flies may rather be attracted inside the cabin by the light from the openings in the superstructure. Besides, the bend(s) and the fixing cowl will reduce the ventilation efficiency.

The ventilation opening is nicely done, and screened. Unfortunately, there is another big opening on the opposite side, which will affect the efficiency of the pit ventilation.

Case studies: design issues observed on the field

Here as well, the issue is the wide opening in front and in the back of the latrine, which will drastically reduce the impact of the ventilation pipe (see Fig. 6). The ventilation pipe is well designed here, but vulnerable, because not held to the superstructure. The PVC will weaken within months, raising the risk of cracking.

Picture below: The drop hole cover is broken and has not been replaced. Because this superstructure has no roof, the flies will be attracted by the light in the drop hole, instead of converging into the ventilation pipe.

In this nice school toilet design, the ventilation pipes could be 20 cm higher. Provision should be made to replace them after a few years, as the PVC is exposed to weathering.

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Most of this guidance has been adapted from:

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Related documents at UNHCR :

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- UNHCR, 2016. *Household Pour Flush Toilet (SaTo Pan) Design and BoQ*. Technical Drawings D-409/2015a. Link: https://wash.unhcr.org/download/household-pour-flush-toilet-sato-pan/