Testing and developing of desludging units for emptying pit latrines and septic tanks

Summary of findings field work in Blantyre - Malawi

SPEEDKITS

Emergency Sanitation Project

International Federation of Red Cross and Red Crescent Societies

SUMMARY

In this report we present the findings of nine-months field work in Malawi on desluding of sometimes difficult to access pit latrines with sometimes solid sludge. This is a short version of an elaborate report that can be obtained by sending an email to emergencysanitation@waste.nl

The objective of the fieldwork was to recommend a reliable desludging kit suitable to empty pit latrines in emergency situations.

The significance of this topic stems from a water and sanitation gap analysis in which more than 900 professionals from over 40 countries were consulted. In this gap analysis, desludging of pit latrines was identified as one of the 12 most significant gaps in the emergency WASH sector. The significance comes also from the fact that there is a growing realization that - in order for sustainable sanitation to be achieved, especially in peri-urban areas - the complete sanitation chain, including the safe removal, transportation and disposal or reuse of faecal sludge, must accompany the promotion of hygienic toilets.

Within the framework of the Emergency Sanitation Project (ESP) and S(P)EEDKITS, WASTE - with the support of the IFRC the Netherlands Red Cross and the Malawian Red Cross - tested three types of desludging equipment and recommended improvements. The equipment was tested in peri-urban, high-density housing areas and institutional toilets in Blantyre, Malawi, over a nine-month period in 2013 and 2014. The three types of desludging equipment were:

- A vacuum-operated machine with an integrated high-pressure pump for fluidizing sludge and an 800 litres holding tank (called ROM 2).
- A vacuum-operated machine with a 500 litres holding tank (called Vacutug Mk2).
- A diaphragm sludge pump.

We also tested other supporting equipment, including two types of transfer stations (a 3 m^3 rigid sludge tank and a 13m^3 bladder); an independent high-pressure water pump (Karcher) for sludge fluidization; and a variety of nozzles to test for optimal performance. The desludging equipment was tested over 500 times in over 200 lined and unlined pit latrines and a few septic tanks with the removal of over 430 m^3 of sludge.

Fig 1: ROM 2.

Fig 2: Vacutug Mk2.

Fig 3: Diaphragm sludge pump.

SUMMARY

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After extensive modifications we found that it is possible to empty pit latrines with sometimes solid sludge in an effective and efficient way. The key components of this vacuum-operated 'mobile desludging kit' include:

- A fluidizer that can spray high-pressure water at around 60-100 bar.
- Fishing equipment such a hooks to remove rubbish.
- A vacuum pump capable of creating a vacuum of 0.5 bar, with a capacity of at least 2000 litres per minute.
- Three-inch flexible suction and outlet hoses in order to avoid frequent blockages by un-fished rubbish.
- A holding tank of 800-1000 litres to store and transport sludge. The inside of the tank should be easily accessible in case the discharge port becomes blocked.
- The kit should be mounted on a small truck or trailer and the length of the suction pipe and fluidizing hose need to be at least 30 metres to assure accessibility.

Improvements in the logistics of operating the kit, including access to localized disposal (or a transfer station), would make it possible to desludge up to eight pits in one working day.

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1 INTRODUCTION

1.1 Background

During emergencies, the standard solution to deal with sanitation is to dig new pit latrines. When the emergency takes place in existing urban environment, the use of existing latrines could be beneficial in covering the needs. However, often existing latrines are already (partially) full and also new latrines can fill up quickly. Specially in areas were the construction of pit latrines is difficult due to limited space or difficult soils (e.g. rocks) it can be required that latrines need to be emptied. The emptying of existing latrines can be cumbersome as the existing latrines are difficult to access, the sludge in the latrines is 'thick', or the availability of desluding trucks is limited. Hence, the 'normal' procedure to apply vacuum trucks does not work satisfactory. So, not surprisingly, desluding is high on the agenda of humanitarian organizations. The 2013 Humanitarian Innovation Fund 'Gap Analysis' notes: *"Sanitation was high on many of the ranked lists, especially urban and early response sanitation. General sanitation gaps included sanitation promotion and sanitation and hygiene in fragile and conflict-affected environments. Key challenges related to the difficulties in building latrines on rock/snow/ sand/collapsible soils and desludging issues including lack of appropriate equipment, how to extend the use of latrines through desludging and how to treat the sludge or, indeed, use it to advantage (biogas, compost etc. and recycling of wastewater). The need for eco and environmentally friendly latrines was raised more than once."*

Within the framework of the Emergency Sanitation Project (ESP) and S(P)EEDKITS, WASTE with the support of the Malawian Red Cross, the International Federation of Red Cross and Red Crescent Societies (IFRC) and the Netherland Red Cross (NLRC) tested three types of desludging equipment and recommended improvements. The equipment was tested in peri-urban, high-density housing areas and institutional toilets in Blantyre, Malawi over a nine-month period in 2013 and 2014. We report on the findings in the presented report.

1.2 Acknowledgements

This report is prepared by WASTE and NL Red Cross Advisers as part of the Emergency Sanitation Project (ESP) and the S(P)EEDKITS Project. The ESP project is funded by the US Office for Foreign Disaster Assistance (OFDA) and is a consortium of the International Federation of Red Cross and Red Crescent Societies (IFRC), WASTE and Oxfam GB.

S(P)EEDKITS has received funding from the European Unions seventh Framework Programme (FP7/2007-2013) under grant agreement No 284931. The NL Red Cross received funding from the Ministry of Foreign Affair and used this for the purchase and shipping of desludging equipment.

The Malawian Red Cross amongst others provided logistical and supervisory support . Part of the funding was provided by SPA (Sanitation in Peri-Urban Areas in Africa), a project implemented by WASTE Advisers and funded by the Dutch Government..

1.3 For the reader

We present an overview of the equipment and the testing procedures in Chapter 2 and the results in Chapter 3. Recommendations for an improved desludging unit are made in Chapter 4.

We invite you to provide us with your feedback by contacting us via:

- emergencysanitation@waste.nl
- emergencysanitationproject@gmail.com

2 EQUIPMENT TESTED AND PROCESSES USED

With the objective to recommend a reliable desludging kit to empty pit latrines in emergency situations, three types of desludging equipment were tested in Blantyre City (Malawi). The equipment was pre-selected based on the functional requirements developed in 2012[1]:

- Vacuum-operated machine with an integrated high-pressure pump for fluidizing sludge and a 800 litres holding tank (called ROM 2).
- Vacuum-operated machine with a 500 litres holding tank (called Vacutug Mk2.
- Diaphragm sludge pump (Lombardini diesel engine).

These equipment were tested during 9 months, starting in September 2013, in peri-urban areas, high-density housing and institutional toilets, removing 430 m^3 of thick sludge in over 200 lined and unlined pit latrines and a number septic tanks. The parameters evaluated during testing period are: design, effectiveness & efficiency, ease of use, reliability and durability.

The main technical characteristics of this equipment are shown in Table 1.

During the first trial, none of the equipment as supplied by the manufacturers proved suitability for removing the thick, semi-solid, rubbish loaded sludge typically found in local pit latrines. However, after extensive modifications and the inclusion of two essential processes: fluidizing and fishing out rubbish, the testing found that it is possible to effectively and efficiently empty difficult pit latrines with difficult sludge under a wide range of conditions.

[1] See:
http://emergencysanitationproject.wikispaces.com/file/view/SpecsDesludging_FinalDraftSuSanAForum_07-11_12.pdf
or
http://forum.susana.org/forum/categories/67-emergencies-reconstruction-situations-refugee-camps-special-conditions-resiliance-issues/2606-results-emergency-sanitation-ws-in-delft-specs-4-suppliers-raised-latrines-desludgingtreatmentdisposal-faecal-sludge#2606

Figure 1. Mobile desludging equipment:

a) ROM 2.

b) Vacutug Mk2.

c) Diaphragm sludge pump.

A

B

C

2 EQUIPMENT TESTED AND PROCESSES USED

Table 1: Technical specifications of desludging equipment

Specification	*ROM 2*	*Vacutug Mk 2*	*Diaphragm sludge pump*
Description	Petrol driven vacuum pump with pressure pump for fluidising. Steel holding tank.	Diesel driven vacuum pump. Steel holding tank.	Diesel driven diaphragm pump. GRP holding tank
Price	€ 15.300	USD 9.730	USD 17.800
Shipment gross weight and volume	500kg; (4.48m³)	869 kg; 5.69 m³	808 kg; 4.69 m³
Propulsion	Truck mounted or trailer	Self-propelled, 3 – 4 km/hr	Truck mounted
Engine type and power	Honda 6.6 kW. Electric or manual start	Unbranded Chinese diesel, 9,1 KW, electric / manual start	Lombardini diesel engine. Manual start
Vacuum pump capacity	Model RV2500. 2,500 litres/min, Kevlar vanes (+ spares). Additional oil reservoir	Make: Pagani 2,750 litres/min Relative pressure: 1.5 bar Vacuum -0.91 bar Max power 7kW	n /a
Pressure pump capacity	Speck Brand 140 bar – maximum pressure - unloaded set on 60 bar. No need for pressurised water inlet. Power requirement 4.1 kW. Capacity 15 litres / minute. Water filter: ½"	n / a	n /a
Holding tank capacity	800 litres	500 litres	No holding tank
Water tank holding capacity	200 litres	0	0
Suction hose diameter	2" and 3"	3"	3"

Specification	*ROM 2*	*Vacutug Mk 2*	*Diaphragm sludge pump*
Suction hose length as supplied	15 m	2 x 15 m	30 m
Hose connectors	Plastic cam locks	Quick release, Metal	Bauer Quick release, Metal
Ball valves	Plastic	Metal	Metal Bauer
Instruction and maintenance manual	Yes	No	No
Spares	Engine spares kit. Vacuum pump spare blades. Hose repair kits	Engine spares kit No vacuum pump spares Hose repair kits	Engine spares kit Spare Diaphragm

2 EQUIPMENT TESTED AND PROCESSES USED

Fluidisation

In general, the nature of the sludge found in most of the tested pits was 'difficult', with very high total solids content (>15%). In order to handle this semi-solid sludge, a fluidization process was developed using pressurized water and specially designed nozzles *(See Figure 2*). Without this prior fluidization of the pit, none of the equipment was capable of removing significant amounts of sludge from the pit latrines. In most cases, the amount of water used during the fluidization process was between 15 – 20 % of the total sludge removed and after fluidization, the solids content of the sludge was tested at around 15%. The quantity of water used in the fluidisation of the pit sludge has a bearing on the efficiency and cost of the operation. A bigger percentage of water used means that less sludge is pumped out of the pit resulting in less operational efficiency and higher transport costs. There are also consequences for dewatering the sludge. To determine optimum pressure and nozzle the project purchased a Karcher HD 1040 B high pressure sprayer with adjustable pressure of 10 to 210 Bar.

The same high-pressure equipment used in fluidising is used to clean the toilet and equipment after the desludging operation.

Figure 2. Spray pattern fluidizer using a 4 jet nozzle at 100 bar.

A) *B)*

Figure 3: a) Fishing tool. b) Fishing out rubbish.

Fishing out rubbish

This is a process that is critical for all types of equipment tested. The thick sludge was invariably found to contain various forms of rubbish. Examination of fished out rubbish revealed items such as old clothes, shoes, bottles, plastic carrier bags, maize cobs, menstrual cloths, medicine bottles and debris from the pit structure itself such as gravel, stones and large rocks from unlined pit walls. The testing regime found that the larger items should be manually removed from the pit with an adapted grappling or fishing hook before pumping out the sludge *(See Figure 3)*. Fishing takes place after fluidization but before sludge pumping, and the process is repeated if necessary. Failure to fish out the rubbish resulted in suction hoses becoming blocked. It was found that 1000 litres of sludge could contain at least 50-100 litres of larger rubbish items. The testing regime found it was not possible to fish-out the smaller items, such as small pieces of plastic, medicine bottles and stones. Over time, these can accumulate in the holding tank and eventually block the discharge ports of the holding tank or get stuck in the ports of the membrane pum. The vacuum-driven machines, namely the ROM and the Vacutug, were found to be capable of emptying sludge with rubbish. While the diaphragm pump functioned extremely well in septic tanks with no solid waste, it proved to be the most sensitive to rubbish and cannot be recommended for this purpose.

3 RESULTS AND RECOMMENDATIONS FOR EQUIPMENT TESTED

After the testing period the following results and recommendations were identified for the equipment tested.

3.1 ROM2

Is a vacuum-operated machine with an integrated high-pressure pump for fluidizing sludge and an 800L holding tank manufactured in The Netherlands Its main specifications are mentioned in Table 1.

This equipment was tested in the following conditions:

- 16 Septic tanks.
- 19 Lined pit latrines in households and schools.
- 60 Unlined pit latrines in households and schools.
- 6 Abandoned pit latrines with very solid sludge.

Problems identified during field-testing

The main problems (experienced during testing period) and modifications applied in the field are:

- 2" suction pipe supplied easily blocked with rubbish → Use only 3" suction pipe.
- Rigid suction probe makes entry into small toilets difficult → Remove rigid suction probe.
- The attachment of the high-pressure hose to the suction pipe made fluidising difficult → Separate hoses and attach fluidising hose to a separate lance.
- Remove ball valve from suction end → and use only suction pipe.
- Replace plastic ball valves with metal valves.
- Replace plastic pipe connectors with metal cam locks.
- Filter from water tank to pressure washer gets blocked → increase size of filter.
- Fuel tank difficult to fill → better funnel.
- Battery difficult to install → relocate terminals.
- After prolonged use or pumping toilets with lots of small rubbish (not fished) outlet to holding tank gets blocked → install man hole in holding tank.
- Fitting ROM 2 on a 3 ton flatbed truck makes access to some toilets difficult → fit to a trailer and increase length of suction pipe and high pressure hose to at least 30 meters.

Key findings & Recommendations

The initial testing demonstrated that ROM 2 was not suitable to remove difficult sludge, however after including the process of fluidizing, fishing out rubbish and some modifications in the equipment the following results were obtained:

- After fishing (approximately 30 minutes) and fluidising (approximately 15 minutes) ROM 2 could empty 800 L from a pit in 4 minutes.
- ROM 2 could empty from a maximum tested suction distance of 30 m and an elevation of 2 m.
- ROM 2 can discharge the sludge in less than 1 minute.
- It has excellent fuel economy of an average of less than 0.2 L fuel per pit.
- It is very reliable – only faults were the drive belts and the pressure hose and water filter.

Based on the findings in Malawi the following recommendations for the ROM 2 can be made:

- Standardise the in the project made adaptations to the ROM (Using 3 inch suction hose only; Remove rigid suction probe; Separate hoses and attached fluidising hose to a separate lance remove ball valve from suction end; Use only metal valves; Increase size of filter in water tank; Relocate terminals of battery; install 4 inch manhole in hol ding tank; increase length of suction hose to 30 meters or more).
- To improve access to difficult to reach toilets, in addition to the 30 m suction hose and pressure hose, the ROM 2 was mounted on a trailer to be towed by any vehicle with a towing capacity of 1200 kg.
- The inspection cover was fitted for ease of cleaning the holding tank from blockages affecting the gauge and discharge (emptying).

3 RESULTS AND RECOMMENDATIONS FOR EQUIPMENT TESTED

3.2 VACUTUG

The Vacutug has a diesel-powered vacuum pump with a 500 L steel holding tank.
The diesel engine also provides power for the self-propulsion. It does not have a separate fluidiser.

The Vacutug could only be tested on pit latrines after the procurement of the high-pressure pump (Karcher). The manufacturer recommended that 'fluidizing' of the sludge be done by first setting the pump to vacuum; then after sucking some sludge, to set the pump to pressure and then blow back into the pit. However, this was considered not suitable for pit sludge in Malawi, as the liquid content was too low. And the concern that this action may cause unlined pits to collapse.

Due to the frequent breakdowns and the lack of mobility of the Vacutug, it was tested on 10 toilet facilities, all unlined pits, removing a total of 7100 litres of sludge:

- Pumping of fluidised sludge: tested effectively to 30 m and an elevation of 2 m. Speed of pumping sludge less than 5 minutes for 500 litres (comparable to the ROM).
- Fuel consumption: recorded as 5 litres diesel per 500 litres of sludge.

Problems identified during field testing

The following problems were identified during Vacutug testing:

- When using its own power (self-propulsion) the Vacutug is very slow at 4kph, it cannot handle even mildly rough terrain or mild slopes, and is unstable. It cannot be licenced to operate on the public roads and cannot keep up with traffic. Due to the slow travel speed work progresses very slowly. This means that while the team managed to pump sludge, the sludge could not be transported efficiently.
- Towing the Vacutug proved slow and dangerous – towing over 15 km took over 4 hours and at one point it tipped over damaging the pressure chamber bracket and breaking the vacuum pump pulley. After this the Vacutug could no longer operate under self-propulsion.
- The starter system of the diesel engine failed – the manual pull started spring broke so that the engine could only start using the battery. Then the battery failed completely resulting in further loss of operating time.
- During the short time it operated under self-propulsion the suction pipe from the tank to the vacuum pump fell on the hot exhaust pipe and melted.

In order to get the Vacutug back to work, the following modifications and reparations were applied:

- Dismantling the 2 parts solved the transporting problem: the tank and the driving side. The tank was towed using a one-ton pick up at normal speed and it proved stable. The driving side (two narrow wheels, engine, pumps etc.) were placed on a pick up.
- As the manual starter broke, and the original battery failed, a different one was used.
- After attempting repairs on the pulley (poor quality workmanship), a new pulley from aluminium was fabricated. After fitting, the engine and pump ran very well.
- The vacuum pump was very effective (-0.6 bar compared to -0.5 bar with the ROM) – so initially it least, it is performing well.

Key findings & Recommendations

Based on the findings in Malawi the following recommendations for the Vacutug can be made:

- Include a fluidiser that can spray high-pressure water of around 60 bar in the latrine sludge. The fluidiser can be mounted on the same chassis as the vacuum pump and driven by the same engine.
- Improve engine quality, preferably it should be reliable, economical and have a good dealer network.
- Improve the safety of the drive system – i.e. operators should be protected from the belts with belt guards and an emergence stop button that is easily accessible is essential.
- Implement a holding tank of around 800 – 1000 litres to store and transport sludge. Our experience is that this size tank is sufficient to make an impact in emptying an average household pit latrine yet remain manoeuvrable in congested areas;

- A gauge (not merely an eyeglass) should indicate the filling progress.
- The unit should be mounted on a small trailer. The company already manufactures and markets a 2000 litre unit mounted on a trailer.

3.3 DIAPHRAGM SLUDGE PUMP

The third type of equipment was the diaphragm (membrane) pump supplied by Butyl, its specifications are mentioned in Table 1.

The sludge pump was trialled mainly on septic tanks as it failed to operate effectively even on fluidised pit sludge. In total 18 septic tanks and 1 pit latrine were emptied using this pump.

Problems identified during field-testing

Over 2 days less than 200 litres of sludge were pumped and the main problem was that the pump could only operate for a maximum of 2 minutes before it stopped pumping, and the following problems were identified:

- On dismantling the pump ports we found small pieces of trash stuck in the ports thus causing the suction side and the delivery side not to seal – therefore the pump was unable build up any pressure – so the sludge just move back and forward with the diaphragm action but did not move forward.
- The dismantling and reassembly of the port took ten minutes – a simple operation. The repair of both ports and cleaning took 30 minutes. But the pump kept blocking in 2 minutes.

Note: it is not possible to fish this small trash out, and neither is it possible to put a smaller size sieve, as the suction would block all the time.

Key findings & Recommendations

- The diaphragm pump is perfectly useable with septic tanks where there is no rubbish and that don't require fluidising. In fact for such an application it may be the best of the 3 machines because it can pump directly to an independent sludge tank or bladder.
- For use in pit latrines, the sludge pump can cope with thick, fluidised sludge for short periods of time, but the ports easily lose their seal with small pieces of trash that can neither be fished out not sieved.
- It can be assumed that the sludge pump can be effective in removing fluidised pit sludge that has no trash;
- Based on the findings in Malawi the supplier of the pump has now proposed a macerator pump that is suitable for use with hard sludge with rubbish as the pump has a shredder. The macerator pump has yet to be tested in field conditions.

4 RECOMMENDATIONS FOR IMPROVED DESLUGING UNIT

The modifications on the most reliable equipment tested in Malawi resulted in the following description of a mobile desludging unit fit for service in difficult conditions. These modifications were subject to long-term testing for pumping efficiency and effectiveness. It is now possible to recommend a design for a mobile pit emptying machine capable of handling most sludge in lined and unlined pit latrines and in septic tanks and able to access a high percentage of toilets. The key components of such a vacuum-operated 'mobile desludging unit' should include:

- A fluidizer that can spray high-pressure water at around 60-100 bar into the latrine sludge using a lance and a special nozzle. For safety reasons, it is not advisable to use pressure exceeding 100 bar. The unit should have a tank that can hold at least 200 litres of clean water for fluidizing and clean-up operations.
- A vacuum pump capable of creating a vacuum of 0.5 bar and with a capacity of at least 2000 litres per minute.
- Three inch flexible suction and outlet hoses in order to avoid frequent blockages by un-fished rubbish.
- A holding tank of 1000 litres to store and transport sludge. The inside of the tank should be easily accessible in case the discharge port becomes blocked.
- The unit should be mounted on a small truck or trailer and the lengths of the suction pipe and fluidizing hose increased to 30 metres to increase accessibility.

Other challenges remain.

Due to the relatively small capacity of the holding tank, transportation to a disposal site is expensive and results in a loss of operational efficiency. Therefore, the setting up of decentralized disposal sites would make the operation more efficient. The equipment is expensive and should be designed with at least some local assembly in mind to reduce capital costs and make the equipment more accessible. The presence of so much rubbish in the sludge, requiring the dirty and dangerous job of fishing, will remain a challenge.

'ROM3' is now on the market.

The work in Malawi has encouraged the manufacturer, ROM, to come up with a device suitable for the 'difficult' sludge in 'difficult' areas. See leaflet on the following page.

4 LEAFLET OF NEW ADJUSTED ROM

Ordinary vacuum trucks are unable to effectively and efficiently empty the hard sludge usually found in pit latrines, so the emptying is often done using manual means that are dangerous for both the operators and the environment. WASTE, The Netherlands Red Cross and ROM bv got together to meet this challenge. The ROM Mobile Desludging Unit is a service unit which is specially developed for emptying and cleaning pit latrines, even those with hard sludge. It is designed and engineered for development aid and emergency aid. The unit includes all proven ROM technology in order to ensure reliability and durability. The low weight of the unit makes it well suited for placement on light vehicles or trailers. You can even transport the unit in the trunk of a common pick-up vehicle.

For emptying and cleaning pit latrines

The ROM Mobile Desludging Unit is ideal for safely emptying and cleaning pit latrines in a very simple and economical manner. The unit has been designed to be easy to operate without danger to the environment or operators. This unit contributes to a higher standard and more durable sanitation systems in developing countries. The unit has proven to be reliable and easy to use in development settings. All common international safety requirements are fully met and features included an emergency stop, over pressure and under pressure safety valves.

For emergency sanitation

Hygiene and sanitation is very important in case of emergency situations. Especially after natural disasters such as earthquakes, tsunami's and hurricanes. In those situations there is an increased risk of epidemics. An adequate level of sanitation can help to prevent an outbreak of communicable diseases. The ROM Mobile Desludging Unit makes it possible to maintain hygienic sanitation and prolong the lifespan of sanitation structures such as pit latrines, elevated or mobile latrines and septic tanks, even in the most demanding situations. The unit can optionally be equipped with a high pressure pump, a lance and specially developed nozzles. This allows the unit to fluidise and pump old sludge with minimum amounts of water. With high quality and functionality, the ROM Mobile Desludging Unit is very reliable, and easy to operate... exactly what you need in an emergency situation.

Several configurations

The desludging unit is available in two configurations:

- 800 liter vacuum tank - 200 liter clean water tank
- 1000 liter vacuum tank - 400 liter clean water tank

WASTE The Netherlands Red Cross SPEEDKITS

ROM bv • Harselaarseweg 63 • 3771 MA Barneveld • The Netherlands • Tel. +31 (0)342 49 04 17 • Fax +31 (0)342 49 28 00 • www.rombv.com

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Mobile Desludging Unit 800 - 200

Drive

- Honda GX270QME air-cooled petrol enginge 6,6 kW / 9 hp
- Electric start system (can also be started manually)
- Sub frame on anti-vibration mounts for smooth running of engine/pump combination

Configuration

- 800l vacuum tank
- 200l fresh water tank

Dimensions

L = 1,50 m
W = 1,66 m
H = 1,35 m

Weight, empty

350 kg (excl. options)

Mobile Desludging Unit 1000 - 400

Drive

- Honda GX270QME air-cooled petrol enginge 6,6 kW / 9 hp
- Electric start system, (can also be started manually)
- Sub frame on anti-vibration mounts for smooth running of engine/pump combination

Configuration

- 1000l vacuum tank
- 400l fresh water tank

Dimensions

L = 1,70 m
W = 1,75 m
H = 1,55 m

Weight, empty

375 kg (excl. options)

STANDARD EQUIPPED WITH:

- Sewage tank galvanised (internally and externally)
- Frame & fork lift pockets galvanised
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WWW.ROMBV.COM

WASTE advisers on urban environment and development
Lange Houtstraat 26
2511CW Den Haag
The Netherlands
tel: + 31 182 52 26 25
www.waste.nl

The Netherlands Red Cross
P.O. Box 28120
2502 KC The Hague
The Netherlands
www.rodekruis.nl