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Low cost latrine emptying vehicle

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The 1980's were designated as the decade of water and sanitation. In many situations, water borne sanitation is inappropriate due to the high costs involved and inadequate supplies of water and a number of United Nations and international aid organisations have been working on improved methods of "on site" sanitation including improved designs of pit latrine.

In the urban areas of the low income countries, and in particular in the un-planned or "peri-urban" areas, land is frequently so scarce that the houses and access roads will take up every inch of space available. These areas frequently develop on low lying or steep land which is unsuitable for the normal expansion of the city, and in these areas in particular there are serious problems when latrines become filled or back up during the wet seasons. Effluent can spread during flooding or is washed down the slopes on to the houses below carrying the organisms which are responsible for many of the endemic diseases.

Efficient and hygienic systems are needed for emptying the pit latrines in such areas where access is frequently extremely difficult and these are the very communities which can least afford high cost solutions.

The density of the wastes in pit latrines will increase with time as the solid materials settle out and the organic material breaks down. This sedimentation is relatively insignificant during the first year or so and such wastes can be handled by conventional vacuum tanker vehicles, but in time these wastes will increase in density and develop a greater resistance to flow.

In 1981 the IRCWD, (The International Reference Centre for Wastes Disposal), initiated a project to study the problems of emptying pits with dense sludges. This study in turn led to the setting up of a test programme to assess the efficiency of different systems in the field.

In 1983 tests were carried out in Botswana on machines from a number of different countries to identify the problems of sucking out the dense wastes found in latrine pits, and to find an appropriate solution. Prototype machines were provided by the British ODA, the Swedish SIDA and private industry in a number of countries. These included conventional low powered vacuum tankers, high powered vacuum tankers with liquid ring and sliding vane pumps, remote suction systems and manually operated diaphragm pumps. The results of these tests have been published by the I.R.C.W.D.

The Botswana tests showed that conventional vacuum tankers with low powered vacuum pumps were incapable of sucking out the dense wastes found in the pit latrines. These wastes are relatively easy to suck to start with, but become more dense and thixotropic with time, so that the longer the pit has been left unserviced the more difficult it becomes to empty. Large and very powerful tankers fitted with very high capacity vacuum pumps using "air drag" or "plug and drag" techniques can suck these wastes, but such vehicles are very costly and the performance of these machines is greatly reduced where long hose lengths are required, and the maximum depth to which they can operate is determined by the height between the sludge in the pit and the top of the sludge in the vehicle tank.

As can be expected, the Botswana tests showed that the more powerful the vacuum pump on any vehicle, the better it was able to suck dense wastes and a lot of information was collected on the effects of different air flows, hose lengths and hose sizes on the suction performance with wastes of varying densities.

High powered pumps require high powered engines to drive them so the pumps and engines are heavy and need to be mounted on large trucks taking up a high proportion of the trucks load capacity. This in turn means that they are costly to buy, to run and to maintain, and due to their size, they have poor manoeuvrability so that they cannot be positioned close to the pits in areas with difficult access.

Thus they require long hose lengths with a lot of bends which in turn increases the friction in the suction pipes. Large vehicles also have large wheels with high chassis and high overall heights restricting access, but more importantly, the increased height of the sludge above ground level dictates the maximum depths which can be pumped as well as making it more difficult to connect and disconnect the hoses.

Thus it can be seen that such high powered vacuum tankers are self defeating. The conditions in Botswana were comparatively easy with good access in most cases compared to many other developing countries, but the tests demonstrated that large tankers cannot reach into areas where there are narrow and unplanned roads with poor surfaces and steep slopes. In any case they are far too costly to be appropriate in the poorer countries where the problems are greatest.

The need was identified for a low cost vehicle with a high capacity vacuum pump which could manouver into the difficult areas; could get right up to the pit latrine so that very short hose lengths could be used, had a low tank height so that it could service deep pits and had the least possible capital, maintenance and running costs so that it could be affordable by low income countries.

Our company had been working on similar problems in the hard to service areas of Trinidad and we were approached by Mr. Jim Wilson, Sanitation Advisor to the World Bank and United Nations Development Programme Technology Advisory Group in East Africa. We were asked to study the results of the tests in Botswana, and the problems of the large cities and small towns in Africa and other parts of the world, and put forward proposals for an appropriate latrine and septic tank emptying vehicle.

Our studies, funded by the Irish Government, included visits to the unplanned or "peri-urban" areas of a number of African cities as well as small towns in coastal, mountain, and desert areas. These studies included an analysis of the servicing facilities available within these countries to make sure that as many components as possible were used with existing spares and service support. We searched all over the world to see if we could find a suitable vehicle chassis on which to base an appropriate vacuum tanker without success so we designed a dedicated chassis and tanker.

Previous studies carried out on behalf of the World Bank have shown that in low and medium income countries, the greatest cost factor in operating vehicles is invariably the depreciation costs of the vehicles and the interest on the capital employed. There are standard depreciation rates which are normally accepted as the economic life, or write off period, of any vehicle and in the industrialised countries trucks are normally depreciated over seven years whereas tractors will be depreciated over ten years. (Of course it is common to see vehicles on the roads which are much older than this but maintenance and running costs increase with age and it is important to distinguish between the economic life and the actual life of any vehicle).

The increased life of the tractor, when compared with a truck, is due to the lower engine speed. (Typically 2,200 rpm for the tractor compared with up to 5,000 rpm for the truck) and a lower road speed which requires a more simple construction and reduces wear on all the moving parts. For this reason it was decided to design a vehicle with a low engine speed and reduced road speed which would have the life expectation of a tractor, and to keep this vehicle as simple as possible for ease of maintenance with the minimum number of moving parts. Thus we would have a long life vehicle with a minimum purchase cost and correspondingly reduced running and depreciation costs.

The capital cost of any vehicle is determined to a large extent by the power and speed of the engine which in turn dictates the strength and type of gearbox, clutch and drive axle used. Modern trucks are designed for high road speeds and require high power to weight ratios but by reducing the top speed and acceleration it is possible to use much lower powered engines and much more basic transmissions.

A typical modern motor car will have a power to weight ratio of around 45 Kw/ton and a modern truck will have a ratio of around 7.5 Kw/ton. However, until only a few years ago trucks were commonly around 5 Kw/ton and their performance was considered adequate. By reducing the top speed, we can accept a figure of around 4 Kw/ton which is roughly equivalent to a farm tractor pulling a loaded trailer.

By using a reduced road speed we can design a vehicle with a high proportion of its weight on the driving wheels to give it the traction to enable it to travel on soft or steep tracks. (A conventional truck,

unladen, may have as little as 30% of its weight on the driving wheels compared with 60% for a tractor, and this, more than the wheel size determines its off road capability).

We were also able to design a vehicle using a rigid beam front axle with a centre pivot. This axle arrangement is commonly used on tractors, construction dumper trucks and other such vehicles and is perfectly satisfactory at the lower speeds involved. It avoids all the problems of a vehicle with suspension systems where torsional loads are transmitted to the chassis and there are considerable numbers of moving parts and linkages, all of which will eventually wear, accounting for the high proportion of vehicles maintenance which is related to the front suspension and steering.

We chose the Lister air cooled engine for reliability and its widespread service back up all over the developing countries. However some countries may have a preference for different engines so we designed a vehicle which can be fitted with a variety of different engines. (In Egypt for example the German Deutz engine is manufactured locally and the vehicle can be adapted to fit this engine).

We studied the different vacuum pumps available and chose a sliding vane pump with a capacity of 9,000 litres/minute. The particular pump chosen is fan cooled to give a long life in tropical countries without the additional costs and complexity of water cooled or liquid ring pumps. We also included a cyclonic separator and grit strainer between the tank and the pump to protect the pump from wear.

The prototype vacuum tank held 1,600 litres of sludge, (although we will increase this to 2000 litres for future vehicles), and a separate tank provides 200 litres of water to a high pressure pump for fluidising very dense wastes and for washing down the vehicles and the latrine area.

The size of the vehicle was determined by the capacity of the vacuum pump necessary to give a good suction performance. This in turn determined the engine power required and the maximum all up weight of the vehicle allowing for a suitable power to weight ratio for adequate road performance.

Four,6 metre lengths of 100mm bore hose can be carried on the truck with quick release couplings to join them as required, (although for most applications it was found that only

one hose was required). These hoses can be used for both sucking up the wastes and for discharging them in situations where the truck cannot reach right up to the discharge area. Separate inlet and discharge valves allow the vehicle to be used as a stationary pump for emptying large septic tanks and pumping the sludge considerable distances.

This is achieved by alternatively evacuating and then pressurising the tank to a pressure of 1.0 bar. A 200mm discharge valve is also provided for fast discharging directly into a sewerage treatment plant and for cleaning out the tank.

The complete tanker is less than 4 metres long and only 1.6 metres wide, about the same dimensions as a small motor car, and it has a turning radius of less than 5 metres. Seats are provided for the driver and two additional crew.

The first vehicle was purchased by the Norwegian Aid Organisation NORAD and air-freighted to Kenya in time for the African Water Technology Conference in Nairobi last year. Since then it has been undergoing continuous testing under a variety of different conditions. These tests have demonstrated that a vehicle, which can be manufactured for less than one third the cost of a conventional vacuum tanker, can reach into areas which could not be serviced in the past, and can service latrines with dense wastes at depths which have not been possible previously at an affordable cost.

Running and maintenance costs were found to be remarkably low and, during one three week period for example, in a small town in Kenya, the tanker was able to collect an average of 33 loads, or more than 53 cubic metres, of wastes per day. The haul distance in this case was about 1/2 Km from the collection to the discharge area and the average fuel consumption was only 6.7 litres of diesel oil per day.

The costs of the fuel, and all other running costs apart from labour during this three week period worked out at just US\$ 0.12 per cubic metre of wastes collected. Even taking labour and depreciation into account, the costs of operating this tanker amount to only a small fraction of those of conventional tankers.

Although the road speed of this vehicle is restricted to 30 km/hr, it has been found that this limited speed is more than compensated for by the very fast turn around times which can be achieved due to the

extreme manouverability and the very short set up, suck out and clean down times due to the short lengths of hose used and the very low tank height.

The relatively high pump capacity, combined with the smaller tank give a very fast "gulping" rate for "plug and drag" operation. In this application the hose is submerged in the wastes until it blocks and a high vacuum has built up in the tank. The hose is then pulled back by hand to allow a "gulp" of air to "drag" the "plug" of wastes into the tank. In practice the gulping rate is dictated by the workers as it is extremely heavy work to pull back the hose against the combined load of the hose, the sludge in the hose and the suction forces.

For this reason we are developing a "gulping attachment" which uses a vacuum cylinder to automatically lift the suction hose as soon as the vacuum in the tank has built up to a pre-determined level. It remains to be seen how successful this system can be in practice, but it has performed very well in simulated tests in our workshop and it is a very low cost attachment

Wherever there are problems with latrine waste there are almost invariably also problems with solid wastes, refuse or garbage, and these are the wastes which harbour the rodents and insects which are responsible for spreading many of the endemic diseases which originate from the faecal wastes.

In the majority of cases the most economical collection system will use small communal containers which can be deposited within easy reach of each household where the inhabitants will deposit their wastes. A small container handling vehicle can then pick up these containers and transport them to the dumping area, or where haul distances are long, to an access point where they can be transferred to a conventional truck for hauling away for emptying.

As there is no suitable vehicle available in the world for this purpose which can reach into the peri-urban areas at an affordable cost, we are developing a very simple vehicles which uses the same basic chassis as the latrine emptying vehicle for this purpose.

Where door to door collection is required, or vehicles are needed which can collect the waste from communal compounds or can collect the heaps of wastes commonly found around the peri-urban areas, a simple tipping body can be fitted to the same chassis.

The vacuum tanker, container pick up system and the tipping truck, all based on a common chassis, can thus provide an integrated and

affordable waste handling system for small towns, congested city centre areas and the unplanned peri-urban areas of developing countries all over the world.

In Conclusion:-

Following the work which had been carried out to identify the problems of servicing pit latrines and septic tanks in low and medium income countries, we were asked to draw up the specification for a suitable vacuum tanker vehicle.

We started out by trying to find a suitable vehicle chassis on which we could mount a high powered vacuum tanker for handling the dense latrine wastes found in the more difficult areas of developing countries. When we could not find a suitable chassis at an affordable cost, we designed a dedicated vehicle on which we could build the vacuum tanker.

The tests which have been carried out to date have shown that a highly manouverable vehicle which can reach right up to the pit is able to achieve very high collection rates at a much lower cost than conventional vacuum tankers and can be an appropriate solution to the problems of the small towns as well as the difficult areas of the larger cities.

Our work in this field has highlighted further problems relating to the handling of solid wastes in developing countries where, once again, there is no appropriate or affordable solution.

Both liquid and solid waste handling problems centre around the need for a transport vehicle with low purchase, running and maintenance costs, which has the manouverability and traction to enable it to travel on narrow and steep tracks and over soft ground where conventional vehicles cannot reach. Previous attempts to solve these problems have all concentrated on the conventional truck chassis with its high cost, relatively short life, high fuel consumption and limitations which are an inherent feature of vehicles which are designed for high speeds and long hauls on good roads instead of a vehicle designed for lower speeds and shorter hauls on the bad roads commonly found in urban and peri-urban situations.