Automatic Working Bio-Toilet Tank for Railway Coaches
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Abstract— Indian Railways was being roundly criticized for creating an environment hazard by discharging toilet waste on tracks. IR coaches have toilet system that has hole on the floor through which human feces and urine is flushed directly on railway tracks. Various types of environment friendly Green toilets have put on outfields trials by Indian Railways to overcome this problem. Controlled Discharge Toilet System (CDTS), Bio-toilet developed by Indian Railways engineers and DRDO biotechnologists, development of Zero Discharge Toilet System (ZDTS) by IIT Kanpur and Research Development and Standards Organization (RDSO) Lucknow, are some efforts in this direction. These technologies are more expensive due to inherent complexities, disposal problem at yards (ZDTS) and requirement of extra infrastructure at the terminal. FFEM approach not only solves these problems but also convert toilet waste into energy which can be utilized further in lighting at platforms or some other useful purposes.

Key words: Bio Digester Tank, PLC Controls, Ball Valve, Flapper/Slider, Flushing Unit, Pneumatic Valve, Piping system

I. INTRODUCTION

Bio-toilets are projected to improve sanitation in the trains to solve the problem of open defecation. Bio-toilets are based on continuous anaerobic microbial digestion of human excreta to biogas. Typical composition of biogas is 55–75% methane and 25–50% carbon dioxide. In these bio-toilets, gases escape into the atmosphere and treated waste water is discharged after chlorination. Bio-toilets welded to passenger coaches have an inlet for human excreta and outlet for biogas. They are an economically viable solution, with one bio-toilet costing Indian rupees 15,000 (US$ 280). There is also a plan of installing these toilets in over 100,000 Gram Panchayats in the next five years. This will help solve the problem of open defecation in rural India. Although this is a good beginning, the concept of bio-toilets in trains will be entirely different from those in Gram Panchayats (houses, schools, institutes, etc.). In the latter case, trapped methane will most probably be used as a cooking gas, whereas in the case of trains it will be released to the atmosphere. The Indian Railways carries 20 million passengers daily and once bio-toilets are equipped in all 53,000 coaches by 2022 as projected, methane emissions will be substantially increased. Methane as a greenhouse gas had a global warming potential of 25 compared to carbon dioxide over a 100-year-period. The Indian Railways may look for engineering solutions to capture and store methane released from the bio-toilets. Vehicles including trains which are successfully fuelled with compressed and concentrated biogas may be taken for case studies. Also, railtoilets are generally small and care should be taken to divert methane out, because it is an asphyxiant and may displace oxygen in an enclosed space.

II. CURRENT SYSTEM

A. Design & Construction

The toilet system offered should be installed in the toilet module as an integrated system, which in case of an emergency, due to the loss of power and/or air, should always be functional.

1) The main system components which will all be in the scope of supply of the supplier are:
- Stainless steel tank with 06 partition wall inside the tank
- Poly grassmats for protection of bacteria inside the partition walls.
- By pass system with handle for operation during emergency for making toilet direct discharge in case of blocking.
- SS fasteners in place of MS on tank covers.
- Stronger bonding of rubber mat with vertical walls

2) Information about IR-DRDO Bio-digester Tank
1) Length -1150 mm
2) Width -720 mm
3) Height –540 mm
4) Total Volume of Tank –400 lt.
5) Effective Volume of Tank –300 lt.
6) Empty Tank weight –115 Kg
7) Full Tank Weight –415 Kg
8) Height from Rail level –220 mm

B. Toilet Bowl

Both Indian squat-pan and Western style commodes are fitted on IR coaches. Seats of Western style commode are 400 - 425 mm above the toilet floor; the Indian style squat pan is mounted on / below the floor, projecting less than 50mm above the floor. The total height of the toilets should be such as to avoid infringement with under-frame members (space available approx. 135mm). The diameter of the toilet bowl outlet hole should be minimum 100mm and shall be so designed to prevent any obstruction in outflow of waste. The toilet bowl design must include an integrated water spray ring system which covers the entire toilet bowl. The toilet bowl should be manufactured from Stainless Steel to AISI 304. The toilet bowl should be aesthetically pleasing. The outlet whole diameter size should be adequate to handle normal waste and some foreign objects thrown in such as bottles, caps, napkins, plastic bags & cups etc. The waste should never be visible or flow backwards into the bowl even in cases of mal-functioning. The system shall, in no case, permit bad odors to escape into the toilets or around the coach. The Biological Toilet system must have the following design and functional parameters:

1) The toilet bowl (Indian and European) must be totally sealed and must be equipped with an efficient water spray ring, which should cover the entire toilet pan in order to provide uniform flow of water in the toilet bowl thus ensuring 100% bowl wash.
2) The toilet system must be provided with an effective stench trap to ensure sealing of odors from the waste treatment tank to the toilet room. The system adopted for odors sealing must be of a proven design which totally seals the space between the toilet bowl and the waste treatment tank and must meet the following operating criteria: During normal operating conditions, when both air and power are available, a water stench trap should always be available between the tank and the bowl. On loss of air and power, the stench trap should always be in the closed position thus ensuring that there is no passage of odors from the waste treatment tank to the toilet room. During non-availability of power and air, the toilet should be fully operable and the stench trap should open to only allow the flow of waste into the tank and thereafter should remain in closed position.

C. Transport Pipe System
All pipes and pipe connections should be made of stainless steel to AISI 304. It should be completely leak-proof and made of non-corroding materials. Line valves should be located for easy accessibility for maintenance, and should be completely leak-proof while in use. Different circuits should be isolated so that repairs in a particular line do not require complete dismantling.

D. Waste Processing
Toilet system shall disintegrate/decompose the waste by the bacteria proliferating due to agents added in it. The system should be able to work satisfactorily even with foreign objects as above. The human waste may be treated in single or multiple stages to ensure complete decomposition. The tendered shall clearly indicate the system for rendering the toilet discharge environmentally inert. Chemicals used in the toilet if any, shall be dispensed in such a manner that there is no chance of their contact with the user. The media used in the waste treatment tanks should be of proven design. The media must be made of synthetic material which does not absorb any chemicals or detergents. The material should be highly resistant to any chemical reaction and must not allow the absorption and existence of any foreign material in the media. The media must be able to sustain high pressure washing and cleaning of the tank. Documentary evidence of the satisfactory performance of the media must be provided. Details of chemicals/agents, along with their consumption rates and approximate costs, shall be indicated. All the consumables should preferably be available in the Indian market. All the material, chemicals/agents being used should meet environmental standards as applicable.

E. Waste Collection & Processing Tank
The tank shall be of stainless steel to AISI 316L with sufficient capacity for duty cycle mentioned earlier. If under-slung tanks are provided, they shall be of superior quality stainless steel, designed to withstand ballast stone hits and cattle run over by the trains. The tendered shall ensure high quality of material, fabrication and welding, for completely leak proof construction. Level sensors should be provided in the collection tank which can be seen from outside.

The waste treatment tank shall be designed so that the same tank can be installed in either side or end of the coach. The waste treatment tank design must include a separate screen to collect large Non-biodegradable foreign objects. This screen must be designed so that it can be easily cleaned during regular maintenance to remove such non degradable objects without the maintainer coming into contact with human waste. A proven positive venting system must be provided in the waste treatment tank for proper functioning of the biological waste treatment tank. The maintenance requirement of the toilet system should be clearly spelt out by the supplier. The maintenance should be done at the time of the maintenance schedules of IR as given in the annexure. The waste treatment tank shall be so designed that it should be possible to clean the tank and service it without removing the tank from the coach during POH.

III. Conclusion
Sanitation in Indian Railways had become a need of time and an important aspect for Indian Railway’s complete success.

Responsible authorities are also putting efforts in this direction by carrying out outfield trials and putting notice board in toilets such as requesting passenger not to use flush when train is stationary at platform.

Our proposed model (FFEM) will not put any restriction on its user. Passengers can use toilet when they want, even if the train is standing on the platform. Also it converts human solid waste to biogas energy which can be utilized in lighting the lamp post at the platform (as requirement) or some other useful purposes. Approach of this model will not only solve the world’s biggest open toilet problem (Indian Railways) but gives alternate source of energy.

REFERENCES
