Toilet systems in Indian Railways

by: J. P. Singh, Prof. / Mech.

Railway toilet system, the world over

- Majority of the Railways, over the world are still trying to overcome the "drop chute system". i.e. Russia, China, Egypt, Turkey, Bulgaria, Latvia are flushing on the railroads
- Whereas, some developed countries have both serviceable retention tanks with vacuum toilets (similar to aircraft) in newer rolling stock, with direct flush to track system in older rolling stock i.e. UK, Italy, Germany, high speed trains in China
- some countries have completely changed to retention tank & vacuum toilet, i.e. USA, Japan, France. These systems require service like aircraft, where a service vehicle empties the retention tanks (for disposal), and recharges the system with chemicals and dye

Railway toilet system, the world over

- The first drawing is from U.S. Patent 1,166,192 A, showing that in 1915 people were working on this problem. This design still drops the waste onto the tracks, the patent describes a method for the brakeman or other train staff to disable the flushing mechanism while the train is passing through a city. But once the flushing is re-enabled, it simply dumps waste onto the tracks
- People have been working on improvements on the simple drop chute design. For example, US Patent 1,325,310 from 1918 describes a train toilet design with a holding tank. The holding tank, partially filled with water, collects waste from the toilet. When the train reaches a speed of 40 miles per hour, the electrical solenoid energizes and pulls the stopper loose, allowing the tank to drain onto the tracks

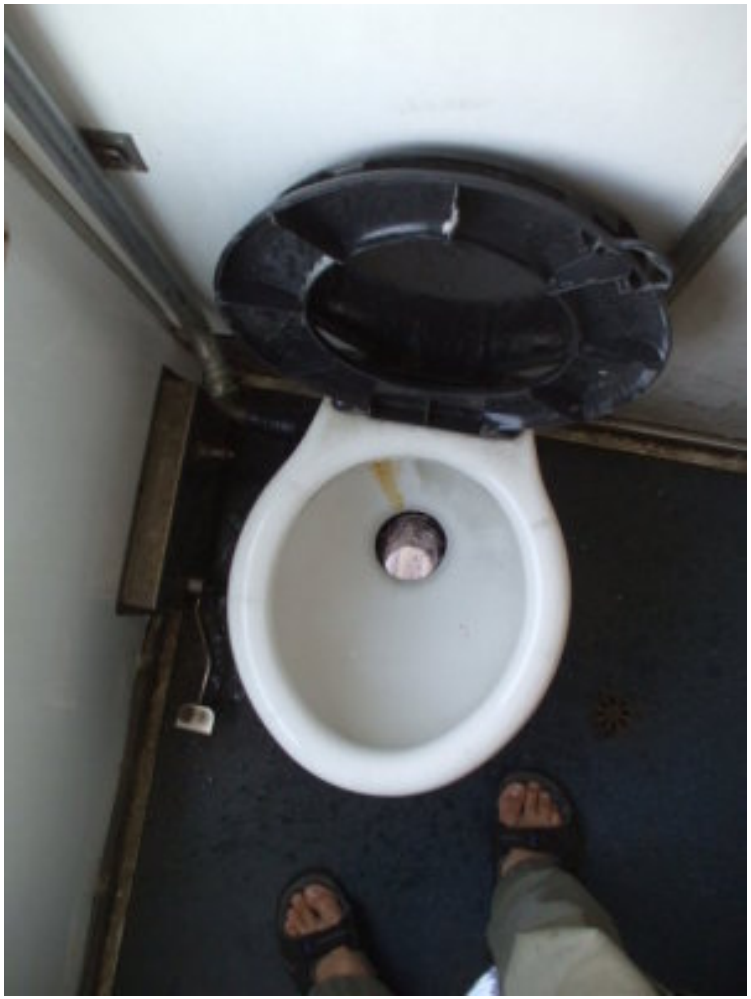
Some toilets system (vacuum)

Thalys, Belgium

TGV, France

Some toilets system (direct flush)

Bulgaria



Turkey

Toilet system in Coaches of IR

- Toilet system is THE most important amenity available in coaches
- 50000+ coaches would mean more than 200,000 operational toilets on the move
- Of these, about 1/4th of the coaches are still fitted with conventional toilets (drop chute system)
- The problem is not unique to India, a large number of Railways around the world are still using drop chute type toilets.

Toilet system in Indian Railways

- Conventional (Drop chute) type
- Controlled Discharge Toilet System (CDTS)
- Zero Discharge Toilet System (ZDTS)
  - Vacuum Toilet System
  - Chemical Toilet System
  - Bio-Toilet (Green toilet) System
  - Hybrid Vacuum Toilet System

Conventional type

- End of commode is fitted to HDPE chute, which outlets directly on the tracks.
- Air channel at the end to chute to prevent air rush upwards through the chute (while on run).
- 3+ liter water is required for each flush.
- Acidic contents cause corrosion to under-gear equipment, tracks and some elements of cross members.

Conventional type

- Very unhygienic, pathogen getting spread all over
- Ugly sight and smell in Platform lines
- Major cause of corrosion
- This system is still continuing in most of the trains presently
- Very easy to maintain, low cost to install and repair

CDTS

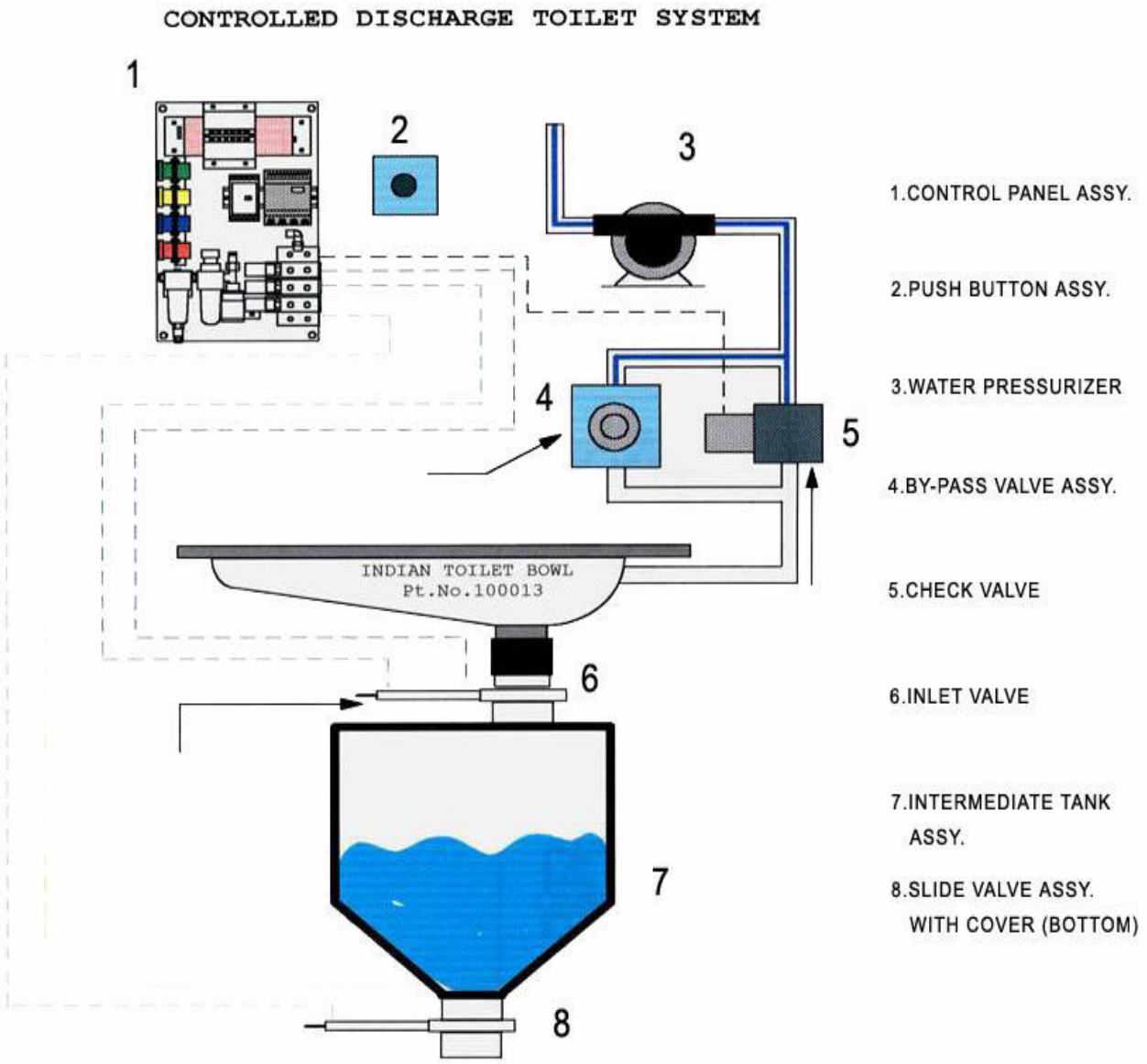
- Control Discharge toilet system (CDTS) has been introduced on Indian Railways to eliminate spillage of toilet waste in Railway station area and populated area of city.
- This toilet system is designed to operate on the principle of high flush, through which the evacuation of toilet bowl is carried out by means of water pressure.
- It operates with a pressurized water bowl wash that covers 100% of the toilet bowl area.
- The toilet waste is transferred to the retention tank with a control amount of water.

Salient features of CDTS

- It's easily programmable and reprogrammable
- Less Air, Water and electricity
- Fully P.L.C Controlled.
- Easy to clean.
- Hygienic, improves environmental conditions at Railway stations.
- Eco-Friendly

How does it look like

Schematic of CDTS



Working principle of CDTS

- This system works on electrical & pneumatic pressure arrangement. The retention tank which stores effluent has two openings. These two openings activates by double acting pneumatic cylinders fed by Feed pipe of air brake system.
- Upper opening opens every time the user operates the flush button, whereas lower opening at predetermined speed & after predetermined no. of cycle of flushes.
- The solenoid/magnetic valves control the entry of pneumatic pressure in pneumatic cylinders attached to openings/slides

Major components of CDTS

- Indian & European toilet basin with flush nozzles
- Control panel
  - Programmable logic controller (PLC)
  - Solenoid valve
  - Control relay
- Retention tank (with flapper & Slide valves)
- Flush button
- Water Pressurizer

Major problems of CDTS

- Maintenance requirement is high
- Water pressurizer malfunction
- Slider valve malfunction, damage by ballast
- Wear and tear of electronic components
  - GPS module, Relay, Solenoid
- Lack of trained personnel at C&W depots
- Splash of effluent on under gear
- The issue of corrosion is not solved

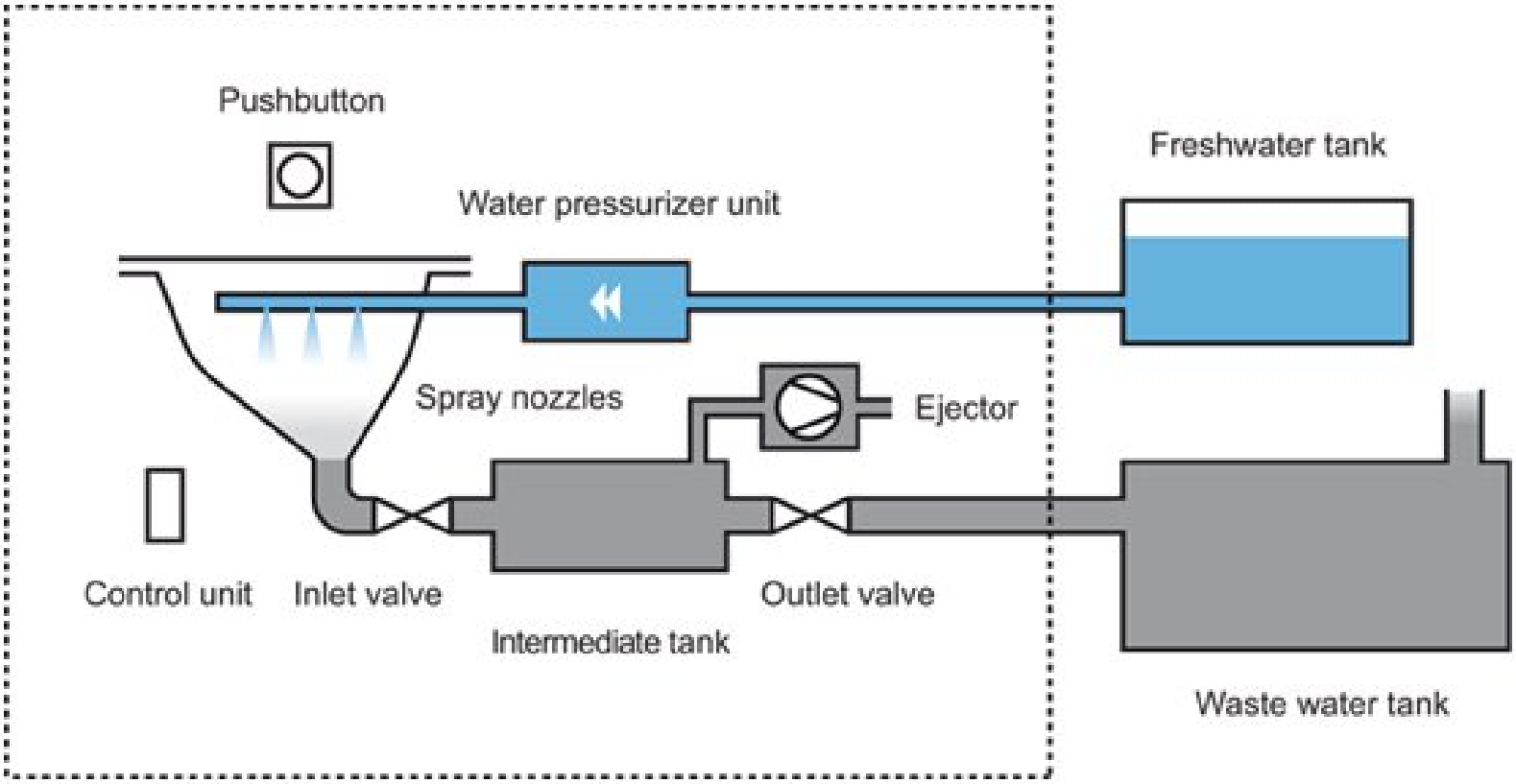
Vacuum Toilet System

- Spec. No. C-K411, RDSO/2010/CG/1
- Can be used to pump un-macerated sewage to a holding tank or transfer it onwards to a septic tank
- Has double check-valves and can therefore also be used in vacuum toilet systems
- Used in many foreign countries
- Require infrastructure

Vacuum toilet in IR

- It is envisaged to conduct trials with vacuum toilets on 2 LHB Shatabadi rakes to be based at New Delhi Coaching Depot of NR.
- Trial of Vacuum Toilets to be carried out in high end coaches in two/three rakes of Shatabdi with ground evacuation facility at NDLS and mobile evacuation facility at other end in case of emergency.
- RDSO & N.Rly were tasked with finalization of specification.

Working principle



The specification called for…

- Clean, odour-less, hygienic and aesthetically pleasing toilet
- No discharge of waste
- No spillage of wastes on the bogie parts, undergear or track
- Minimum life cycle cost to IR

Specification

- Lavatory bowl (Oriental/European design).
- Flushing arrangement including interfacing for water, compressed air supply,
- Retention Tank
- Control panel and associated ancillaries for the system operation.
- Associated water hoses, pneumatic piping and electrical wiring .
- Ground facilities required at the terminals

Chemical Toilet System

- Spec. No. C- K410
- Used in aircrafts
  - Type 1: The toilet waste of this **fully-installed system** drains into a permanently-fixed storage tank (and mobile mounted tanks) that is emptied by draining through a knife-valve outlet under the carbody
  - **Toilet chemicals** These are commonly solution concentrates, occasionally powders. All are dyed to reveal spillage, and to warn users that there are hazards associated with improper handling. There are biocides, thickening agents, surfactants, stabilisers, and perfumes in these products

Similar to a system used in aircrafts

Line side emptying modules

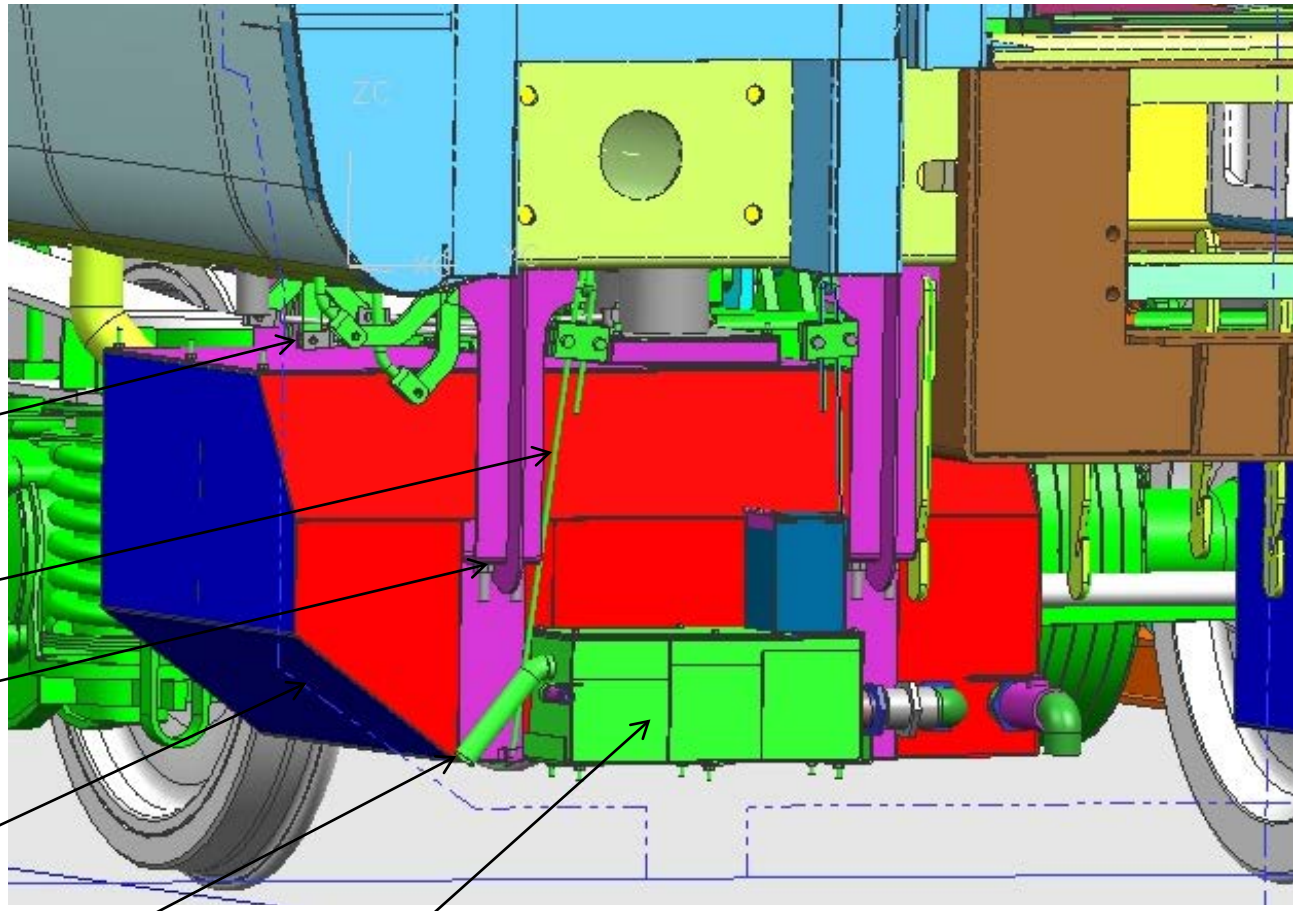
Emptying system – Line Side Modules

Mobile emptying modules

Bio-Toilets (Green Toilet)

Bio-toilet

Bio-toilet



OPENING MECHANISM FOR BALL VALVE

SAFETY WIRE ROPE

MOUNTING BRACKET

BIO DIGESTER TANK

FINAL DISCHARGE POINT (AWAY FROM RAIL)

RE-DESIGNED DETACHABLE CHLORINATOR

Environment friendly Green Toilet

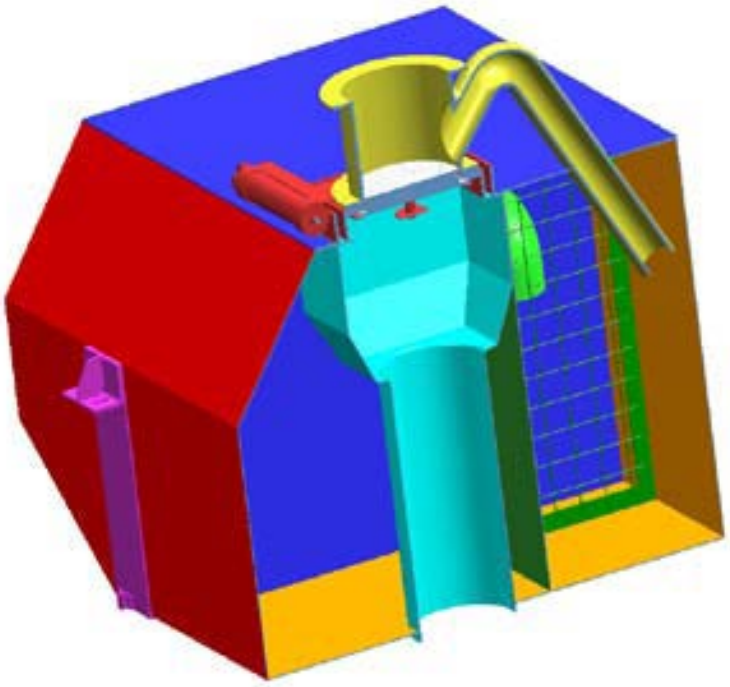
- Environment friendly.
- Preventing damages to tracks due to corrosion.
- Improved aesthetic at Railway stations.
- Require less maintenance.
- Simple in design.
- Easier Retro fitment on existing coaches in service.
- Can be in operation upto years together

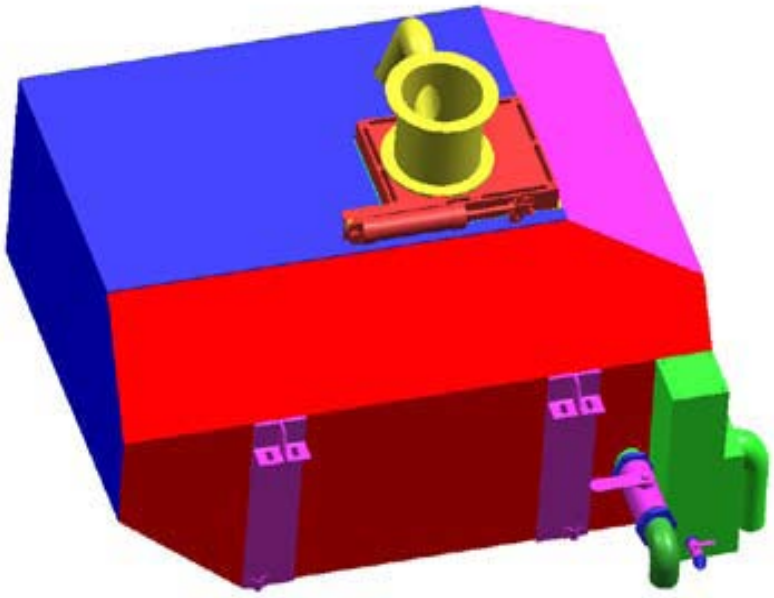
Strategy

- A multi directional strategy has been formulated for fitment of environment friendly toilets on all IR passenger coaches by 2021
- As per the commitment to Supreme court, Indian railway in association with IR-DRDE developed a anaerobic bio-toilet tailor made to Indian railway passenger coaches in March 2010 by forming a joint working group consisting of IR Engineers and DRDO biotechnologists .
- Till date four design variants were jointly developed by IR & DRDO.

Variant-I

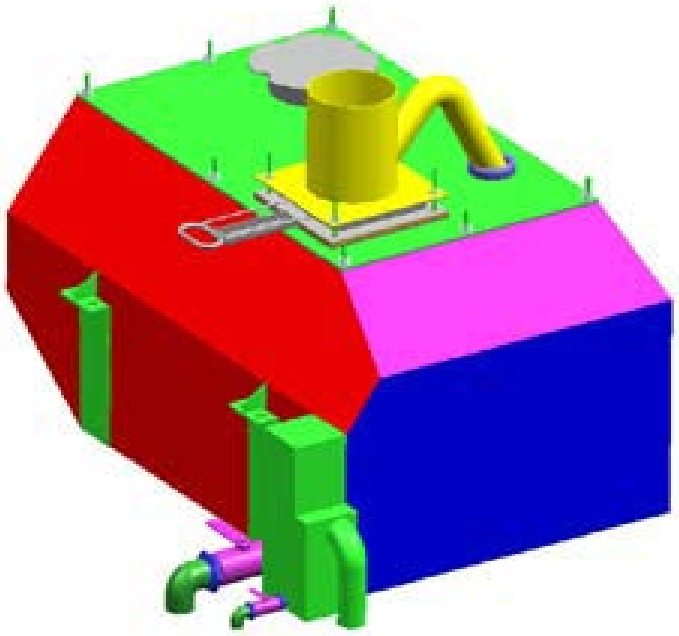
Brief description	Features			
	Pneumatics	Electronics	PLC	Flush
System with flapper valve	Yes	Yes	Yes	Pressurized

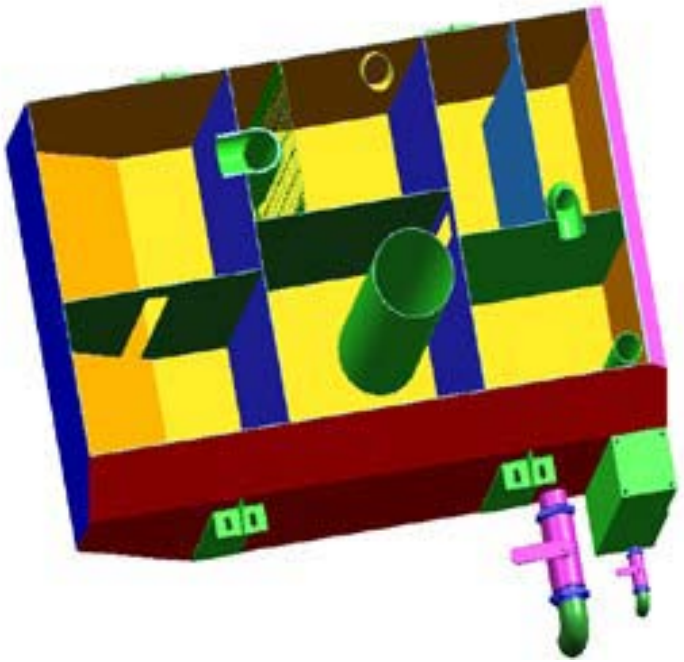




Variant-II

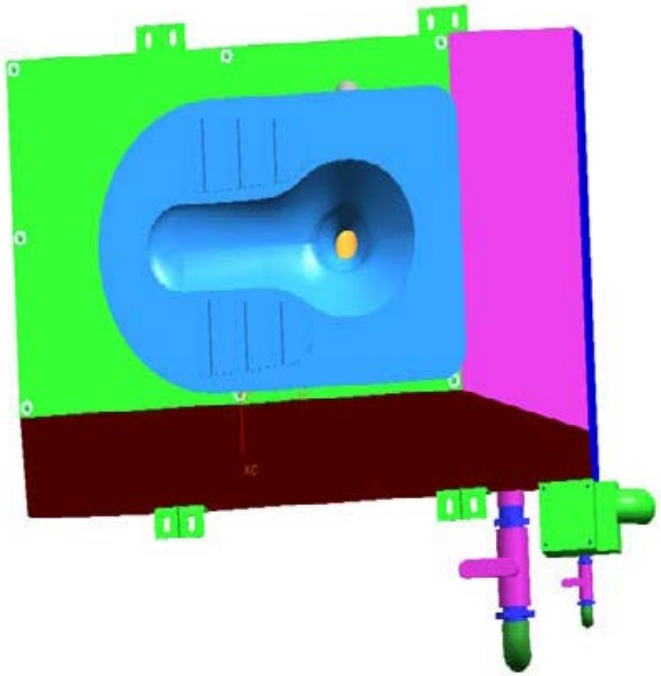
Brief description	Features			
	Pneumatics	Electronics	PLC	Flush
System with manual slider valve	No	No	No	gravity

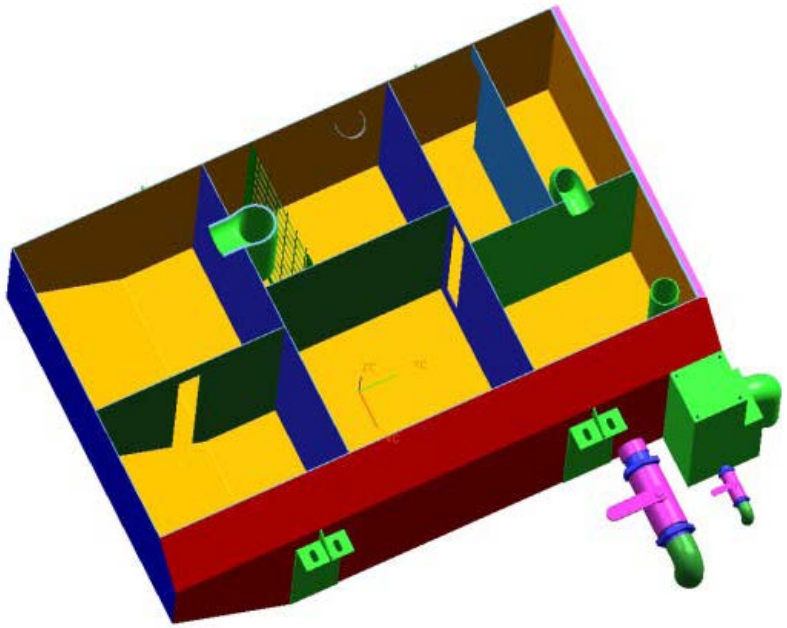




Variant-III

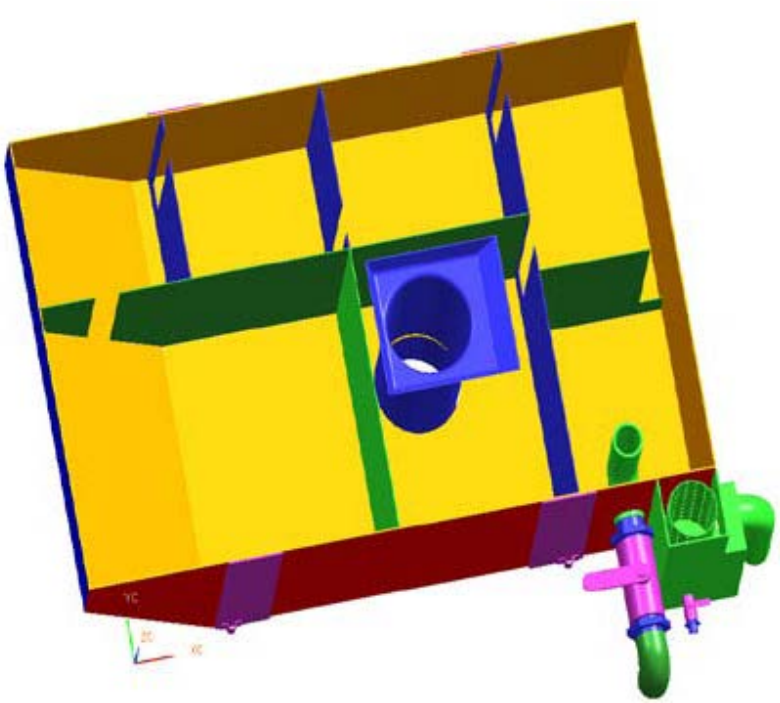
Brief description	Features			
	Pneumatics	Electronics	PLC	Flush
System with reduced opening at inlet For western style Hind ware commode is proposed	No	No	No	gravity

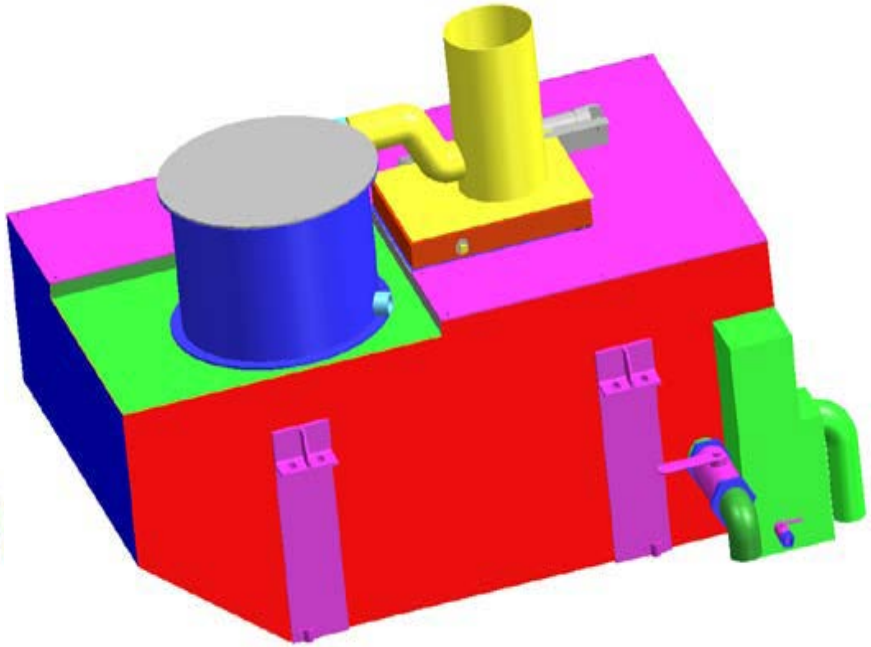




Variant-IV

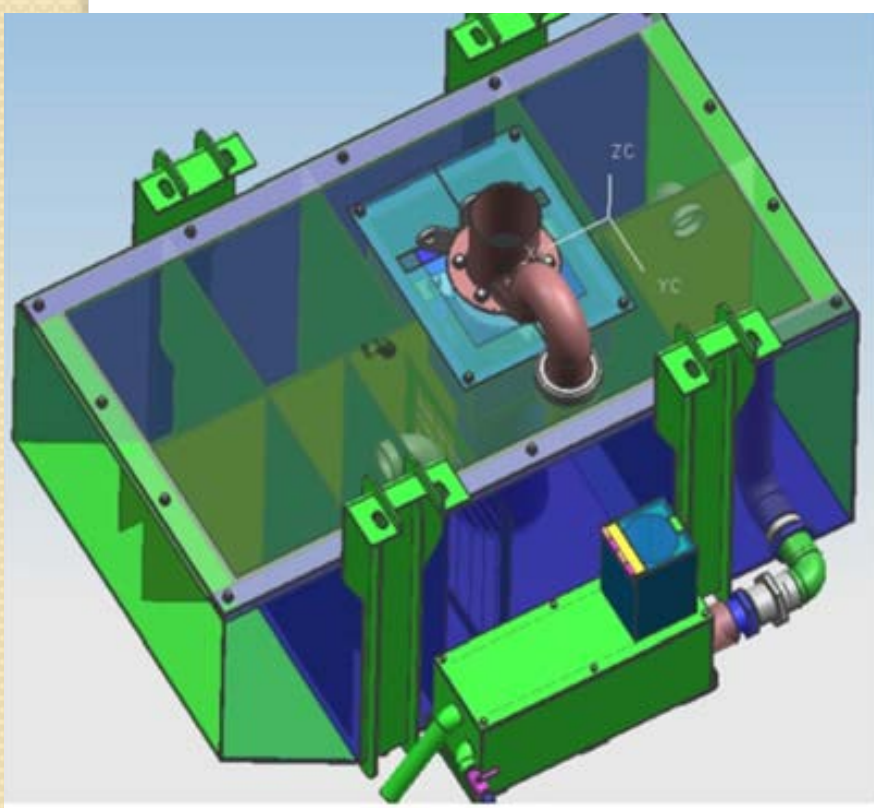
Brief description	Features			
	Pneumatics	Electronics	PLC	Flush
System with solid liquid separator	No	No	No	gravity

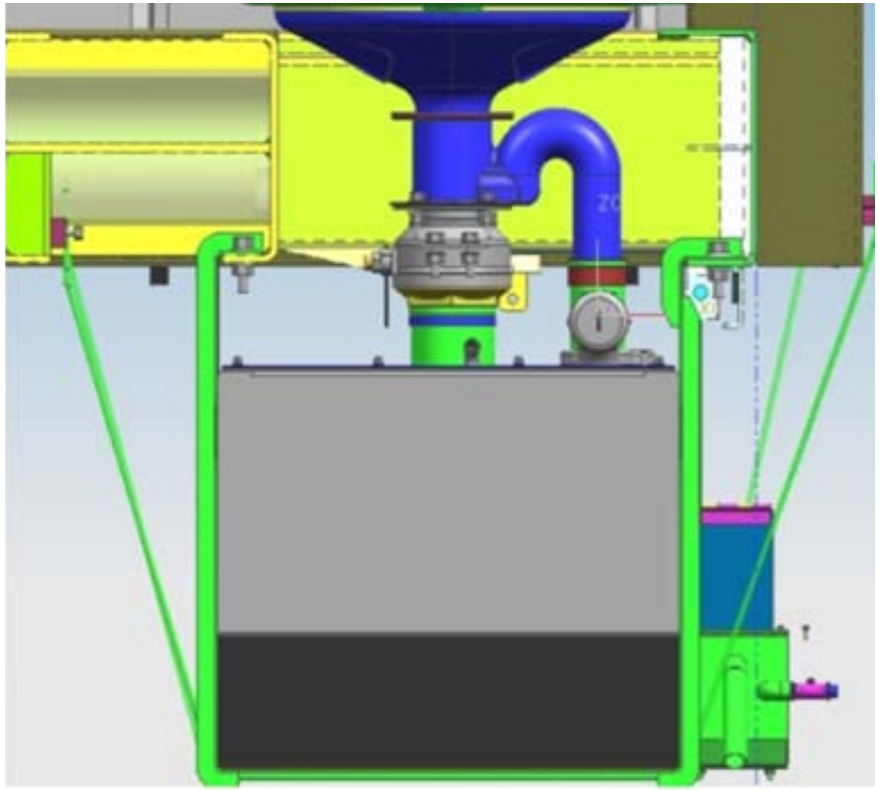




Variant with ball valve

Brief description	Features			
	Pneumatics	Electronics	PLC	Flush
System with Ball valve	No	No	No	gravity



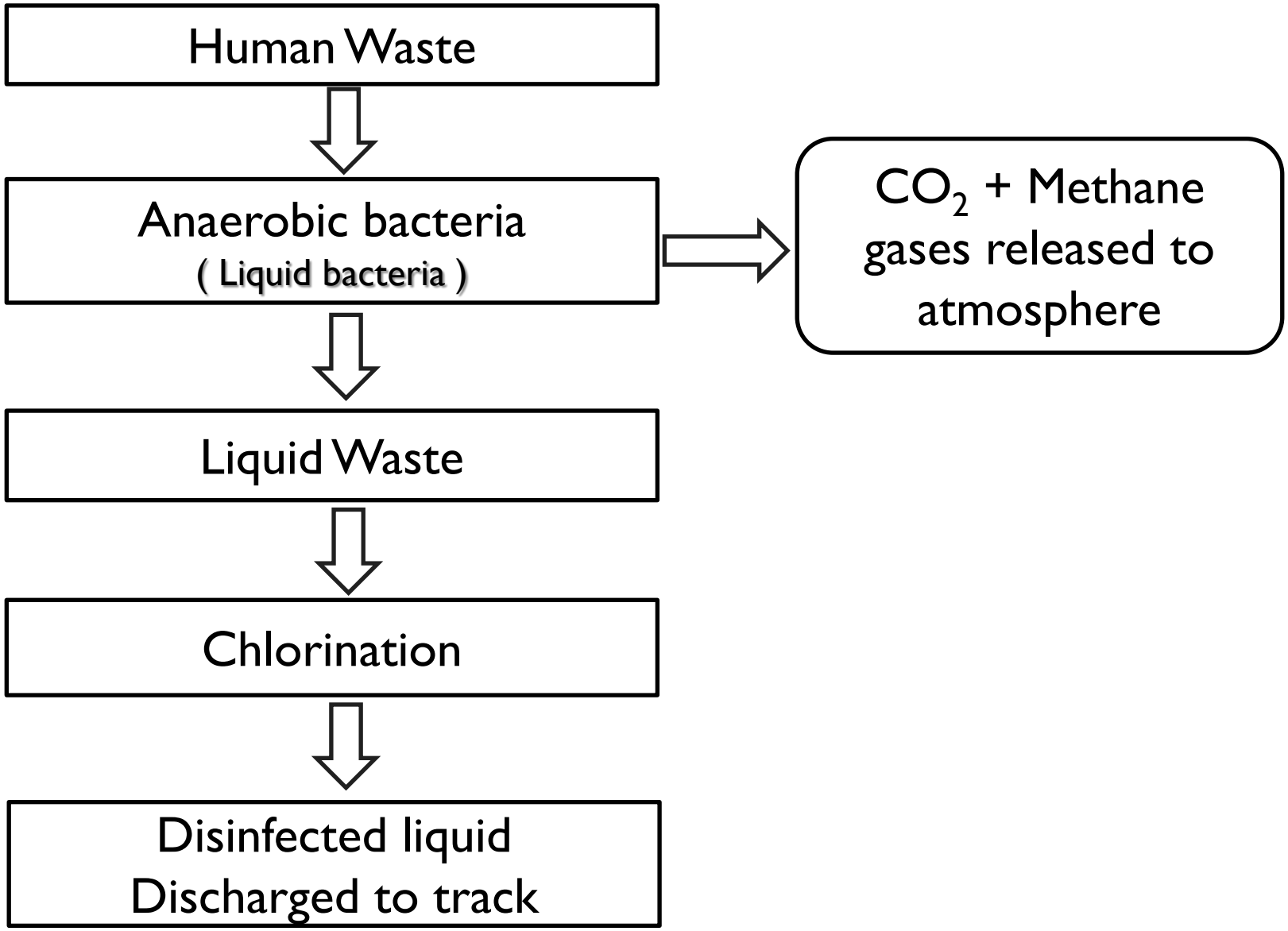


Difference between aerobic and anaerobic process

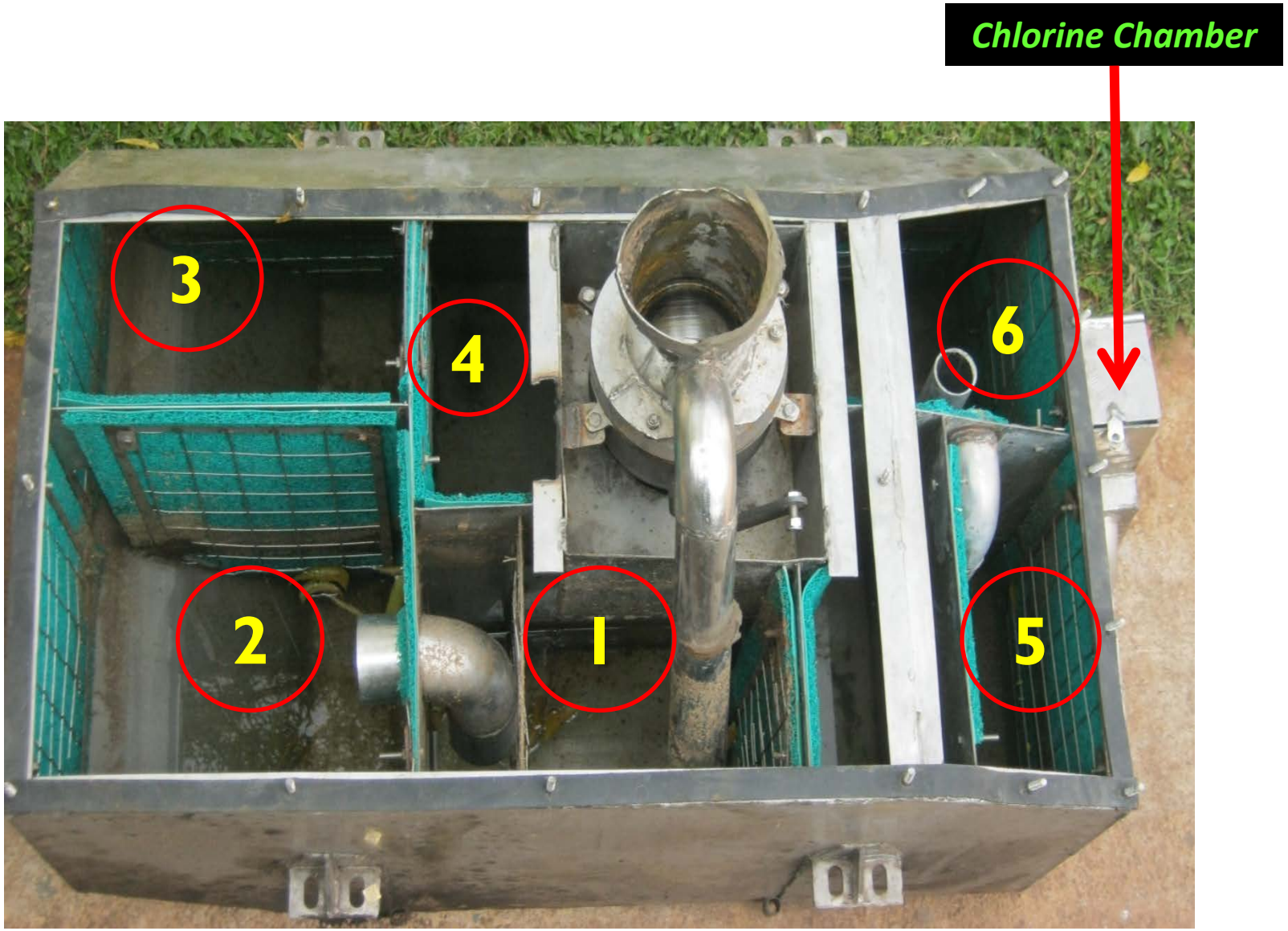
Strictly speaking, the terms "aerobic" and "anaerobic" refer to the presence and absence of oxygen, respectively

Aerobic biodegradation V/S	Anaerobic biodegradation
Forced aeration/ agitation is essential and is energy intensive	No aeration is required
Incomplete aeration (partial aerobic condition) leads to foul smell	Complete anaerobic conditions
Not effective in pathogen inactivation	More than 99% Pathogens inactivation
Can not tolerate detergents/ phenyl	Anaerobes can even degrade detergents/ phenyl
Generates large amount of sludge	Sludge generation is very less
Repeated addition of bacteria/ enzyme is required for the process	One time bacterial inoculation is enough
Maintenance & recurring cost is high	Minimal maintenance & no recurring cost

Working of Bio-Toilet



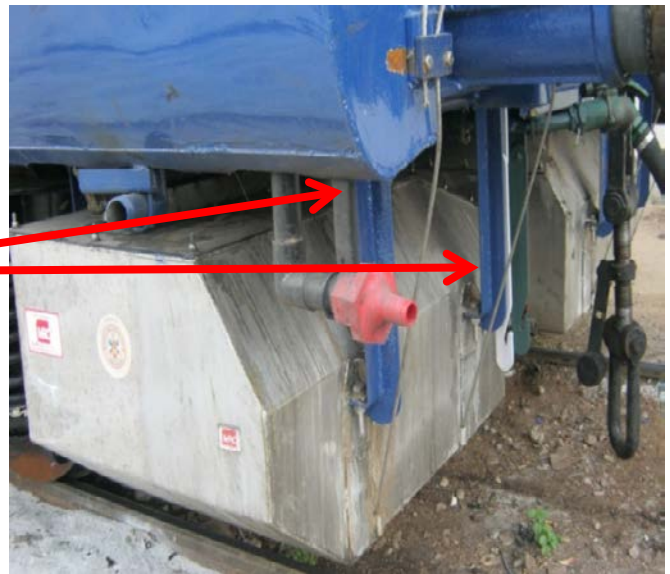
Main parts of Bio-digester tank



IR-DRDO Bio-digester Tank for Coaches

- These tanks are made of stainless steel and having following constructional features:
- Tanks are made of stainless steel.
- Size of the tank is 540 x 1150 x 720 mm.
- Provision of 04 Nos. mounting brackets at both the sides.
- Each bracket is provided with 02 nos of M16 bolts. The tank is secured with 'J' brackets.
- Current procurement cost of each toilet is Rs.63 thousands approx.

J - Brackets

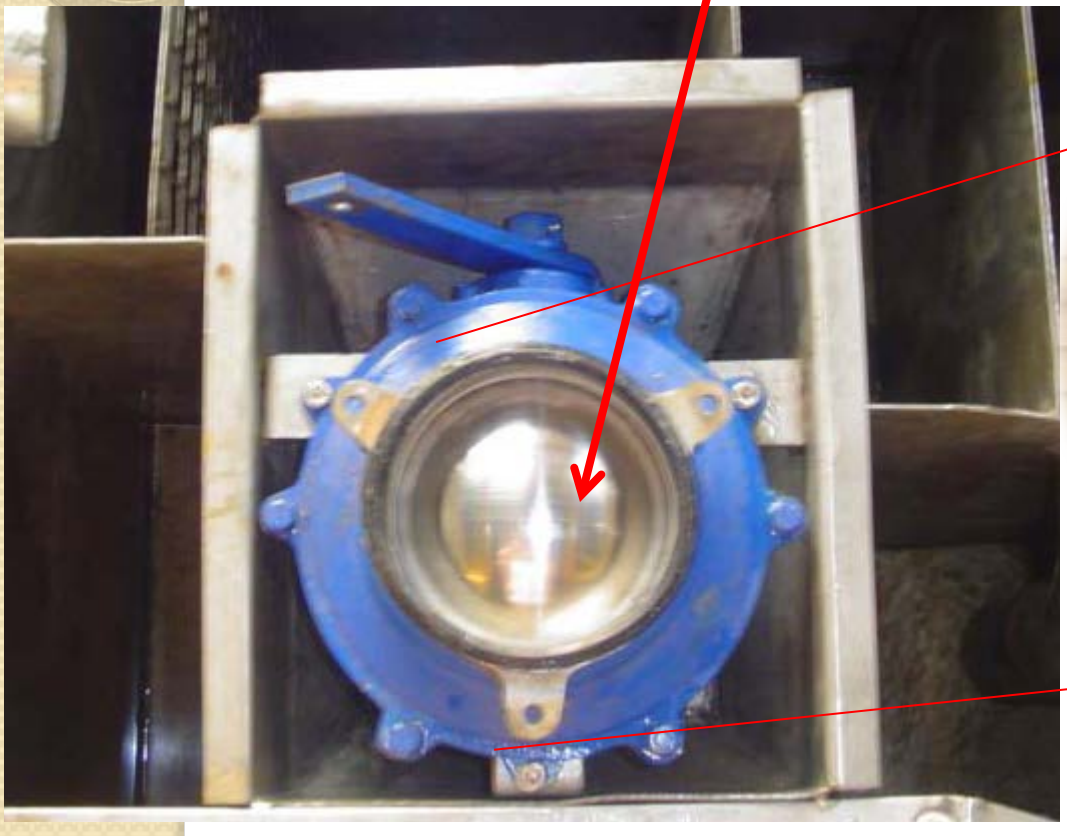


Bio digester tank

2. Mats for nesting of bacteria:

Bio digester tank

3. Ball valve for direct discharge in case of chocking.

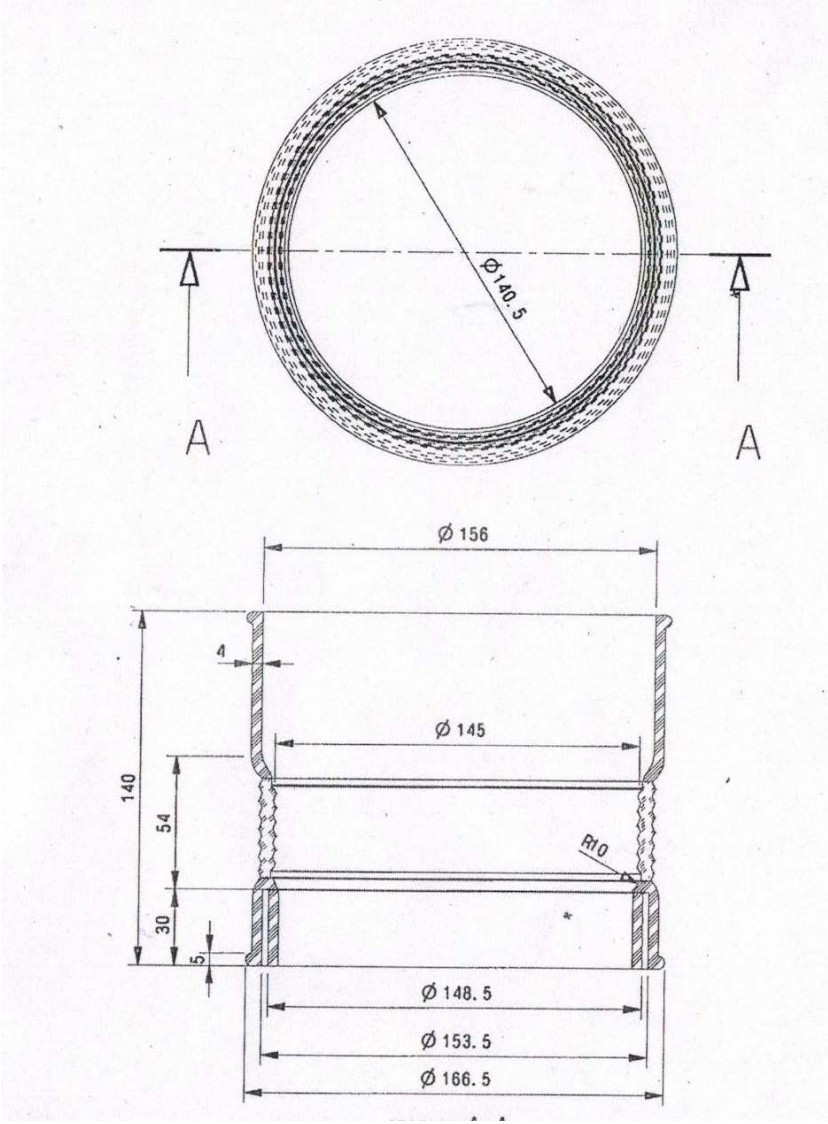


Bio digester tank

5. Loading of inoculums in Bio-tank.

Bio digester tank

6. Drawing for hose connector is approved by RCF this is addresses the alignment up to maximum 30 mm offset



Testing parameters of discharge of Bio-digesters

Effluent Discharge

The system should be designed for discharge of non-obnoxious and odorless liquid matter. The effluent discharge should at least comply with the following pollution control requirements:

- The effluent should have pH value between 6 to 9.
- The effluent should not contain any visible solid mass of human waste.
- The effluent should not contain total suspended solids (TSS) more than 800mg/litre.
- The effluent shall be subjected to chemical treatment and process (es) e.g. chlorination etc. prior to discharge, which will result in a most probable number (MPN) of fecal coliform bacterial density of less than 5000 per 100 ml prior to discharge.

Brief about bacteria – Anaerobic

- **Anaerobic Bacteria**
  - Can double its population with in 06-08 hrs
  - De-composes matter into liquid and gases
  - Can be kept for two-three months at ambient temperature in bio-digester tank
  - Can withstand sub-zero temperature upto -60 degree centigrade
  - Inside processing is not effected by cold atmosphere, as anaerobic process is exothermic in nature, heat will be available inside the chamber of chemical process.

Guide lines for handling bacteria

- Always wear gloves while handling bacterial culture.
- Store bacterial culture in containers with lid which can be closed.
- During transportation lids should be tightly closed.
- During storage, lids should be kept loose, so that the gas generated inside the container can escape easily otherwise container will get damaged physically.
- Do not mix detergents/acids with bacteria at any stage during use.
- Toilets fitted with bio-digesters/ bio toilets should be preferably be cleaned by pressurized water cleaning system so as to minimize the water usage.
- Clean/sanitize hands with detergents/ soaps after handling of the bacteria.

Requirements for Cleaning Agents

- All the cleaning agents used shall be bio-degradable.
- Should be phosphate free.
- Should not be a combustible liquid.
- Should be preferably have near neutral PH value in used dilution.
- Should have soothing fragrance & smell.

It must be ensured all toilet cleaning agents of neutral PH value with bio degradable as specified in COFMOW Compendium only shall be used for cleaning the toilets.

Sampling for Testing of Effluent Discharge

- Sample shall be collected on quarterly basis & sent for testing
- Samples will be collected randomly – from lot of 5% coaches of the total coach holding but minimum one coach of each type – at an interval of every three months during the trial period.
- Sampling will start after coach has been in passenger service for 10 days or more. The samples should be collected and sealed in presence of Railway representative.
- At least one test every quarter shall be carried out in Govt. lab.
- In case the samples do not meet the requirements, test shall be repeated after taking necessary corrective actions within a fortnight .

Procedure of Sampling

- The sample shall be collected in 2 liter plastic bottle by simply opening the knob provided in the sampling port.
- The date and time of sampling and coach no. must be mentioned on the bottle.
- The sample collected in the bottle shall be transported to lab at the earliest but not later than 24 hours after collection of sample.
- The test results shall be furnished in prescribed format .
- Consolidated trial report shall be sent by monitoring railway to RDSO at the end of prescribed trial period.

Summary of Sampling Tests for Bio toilet of Effluent

S. No	Sample Test	Target value
1	PH value	6-9 pH
2	Total Solids (TS)	< 750 mg / 100 ml
3	Total Dissolved Solids (TDS)	< 350 mg / 100 ml
4	Total Volatile Solids (TVS)	< 500 mg / 100 ml
5	Chemical Oxygen Demand (COD)	< 2000 mg O_2/Liter
6	Fecal Coli Forms Count	> 99% reduction (<10^8 /100 ml)

Periodicity :90 days.

Testing Scheme for Bacteria Culture (Microbial Inoculum)

The following four tests have been recommended Microbial Inoculum produced in Inoculum generation plant.

S.No	Description	Periodicity	Target
1	PH value test	Once in a week	6.5 to 7.5 pH
2	Bio gas test	Daily	--
3	Percentage Methane Test	Once in a Week	40 to 70 %
4	MPN count for Methanogens	Monthly	> 1000/- per ml

Preventive Maintenance Schedules

Trip Schedule:

- Attending the routine complaints received from the users.
- Cleaning the toilet and choking to be removed ,if any.
- Checking the complete toilet system for any deficiency.

Preventive Maintenance Schedules

- Schedule A /Monthly examination:
  - All works carried out as mentioned in daily schedule.
  - Visual examination of complete toilet system including under slung equipments.
  - Charging of chlorine tablets and examination of chlorinator

Preventive Maintenance Schedules

- Schedule-B /Quarterly examination:
  - All works carried out as mentioned in A- schedule.
  - Collection and transportation of samples from retention tanks to DRDE, Gwalior or Nominated government accredited lab.
  - Checking of following equipment for repair / replacement for proper functioning

    1. Flapper/Slider/Ball.
    2. Leaking in piping system, flush system charging.
    3. Charging of Bio-culture, if required.

Preventive Maintenance Schedules

Schedule-C/IOH

- All works carried out as mentioned in B- schedule.
- Testing of all toilet system
- Tightening of all nuts and bolts for proper securing of tanks
- Drawing and delivering of samples for six monthly tests to Govt. labs
- Charging of Bio-culture if required based on Test reports

Problems noticed so far…

- Ball valve malfunction
- Laboratories have not been setup in Depots
- Lack of trained staff
- Lack of spares
- Low awareness among rail users
- Abuse
- Delay in formalizing AMC
- Lack of capacity in Workshops

Spares like rubber connectors, clamps, foot pedals are not available in the Coaching depots.

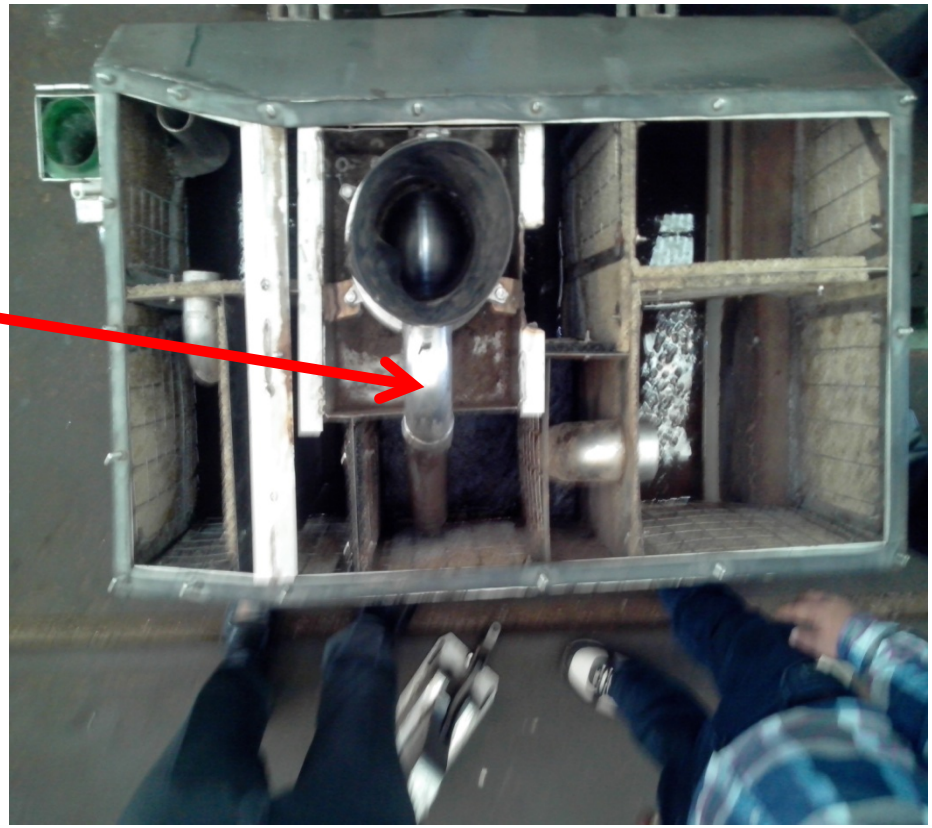
- The above material is not available in the coaching depots for replacement hence bio toilets are made through by opening bal-valve permanently by putting stone below lever stem.
- Standard drawings of all above components to yet be issued by RDSO for procurement.

Chlorinator

Leakage of effluent to be checked from threads of chlorinator pipe

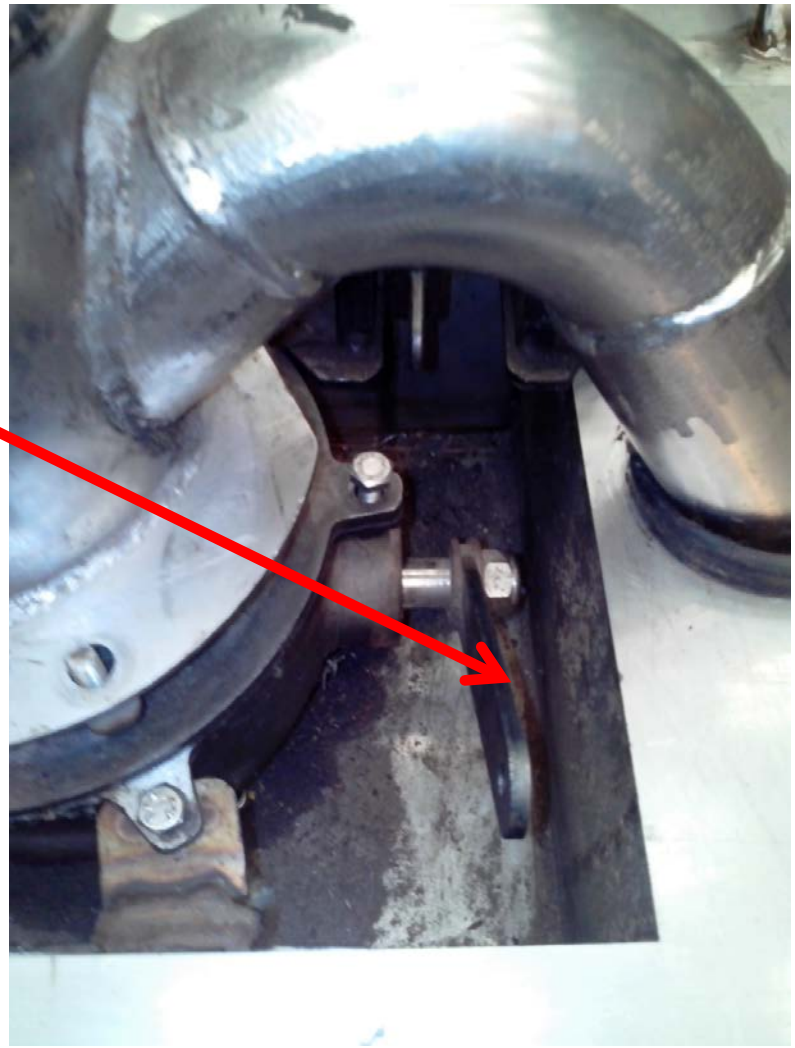
Rubber gasket

Waste material leaking from Rubber gasket due to blocking of bent pipes.



Ball valve shaft

Ball valve shaft nut found loose and lever was not working.



Welding Failure in J-Bracket design

Weld location of bracket

Bracket came out due to weld failure

Welding Failure in J-Bracket design

Welding Failure in J-Bracket design

Tools to be carried

The operator should carry the following tools for

- Maintenance of Bio-toilets:
  - Bottle picker.
  - Polythene bag.
  - Spanner.
  - Pedals of different companies both LH and RH.
  - Hand gloves.
  - Nose mask.
  - Torch light.

Maintenance of Bio tanks

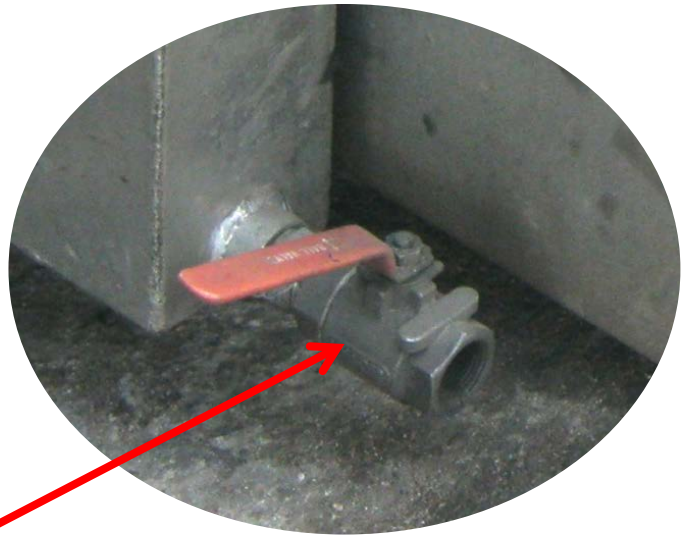
On arrival of the train, jammed toilets to be identified and released on platforms, by operating ball valve.
If jam still persists or ball valve does not operate, the block shall be cleared with the help of bottle picker.

Maintenance of Bio tanks

All pedals shall be operated for ensuring proper functioning of opening and closing of ball valve on maintenance.

Maintenance of Bio tanks

- Check sampling port cocks for missing/theft of Bio-digester tank.



Maintenance of Bio tanks

- Ensure intactness of fasteners of Bio-digester tank.

Trolley Mounted Sewage Suction Machine

Supplier: M/s Vogelsang India, Noida UP
Working at Coaching depot, Gwalior.

Suction Machine

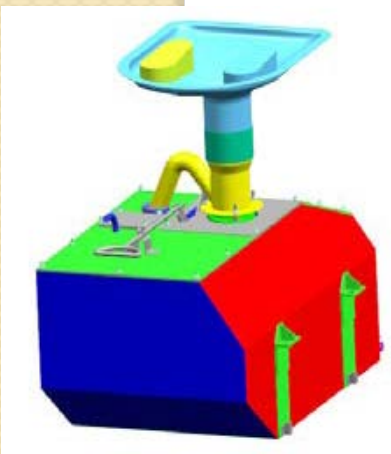
- Trolley Mounted Sewage Suction Machine

Alternate Design of bio-digester tank

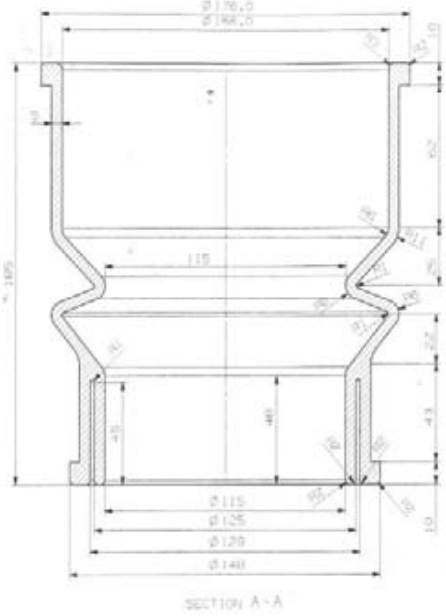
Issues of old design digester:

Following issues were raised by field staff in old design tanks:

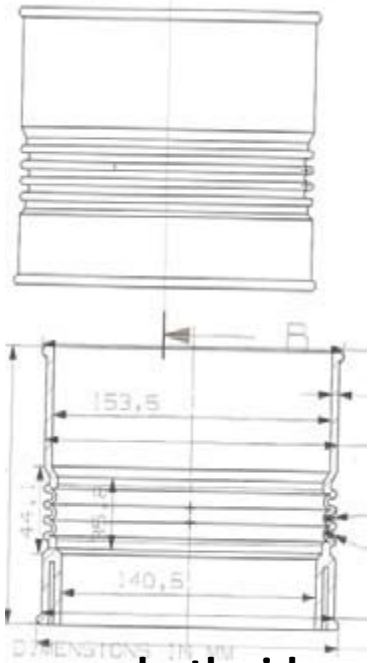
- Shape of connector – difficult to manufacture and prone to damage while cleaning.
- Material proposed as TPE instead of EPDM.
- Differential dia connector 150/125 mm: In old design connector, the dia was same at both the ends, now the dia on top is 150 mm and 125 mm in bottom.



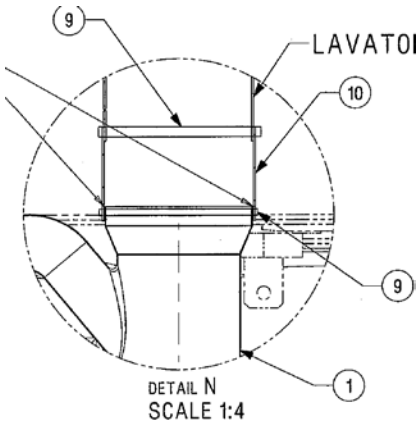
Diameter of pan and P-trap pipe same



Differential dia connector 150/125

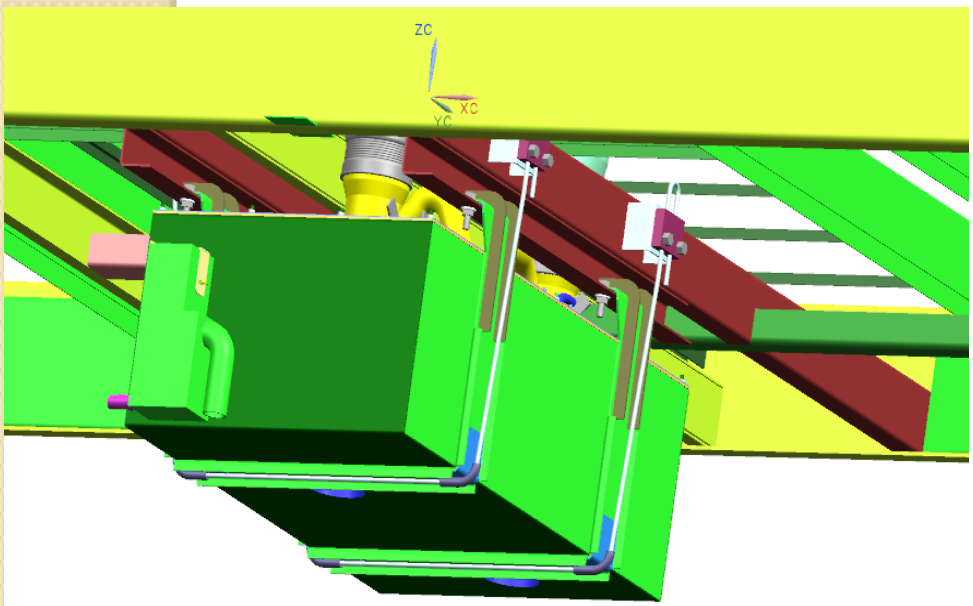


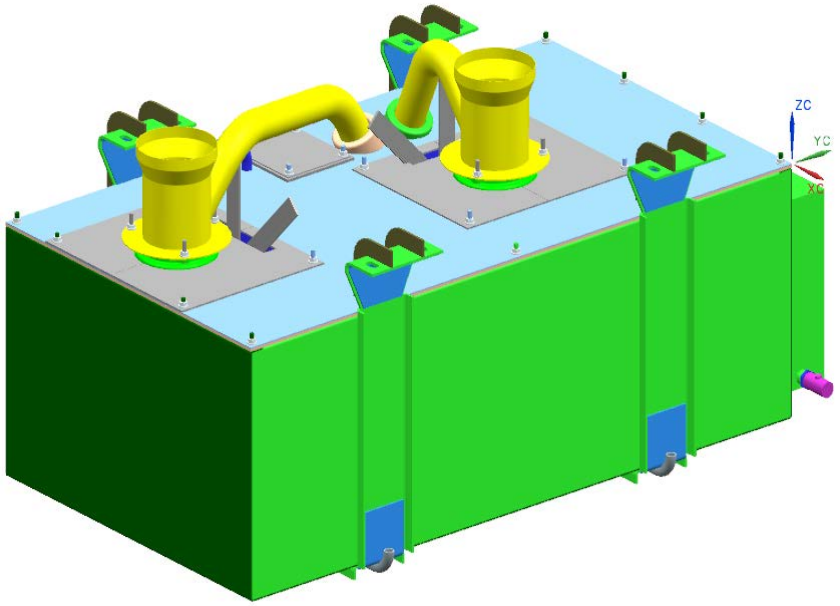
Same on both side with bellow formation



Developments/Improvements (Common Bio-digester tank for DSLR coaches)

- Common tank for passengers and disabled lavatories.
- 50 ltrs retention tanks for Guard compartment.

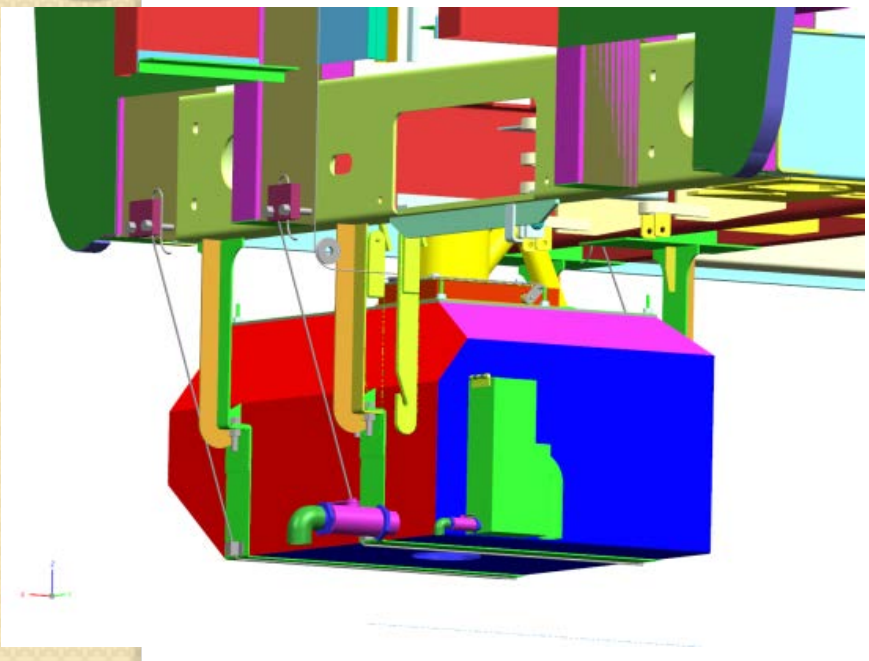




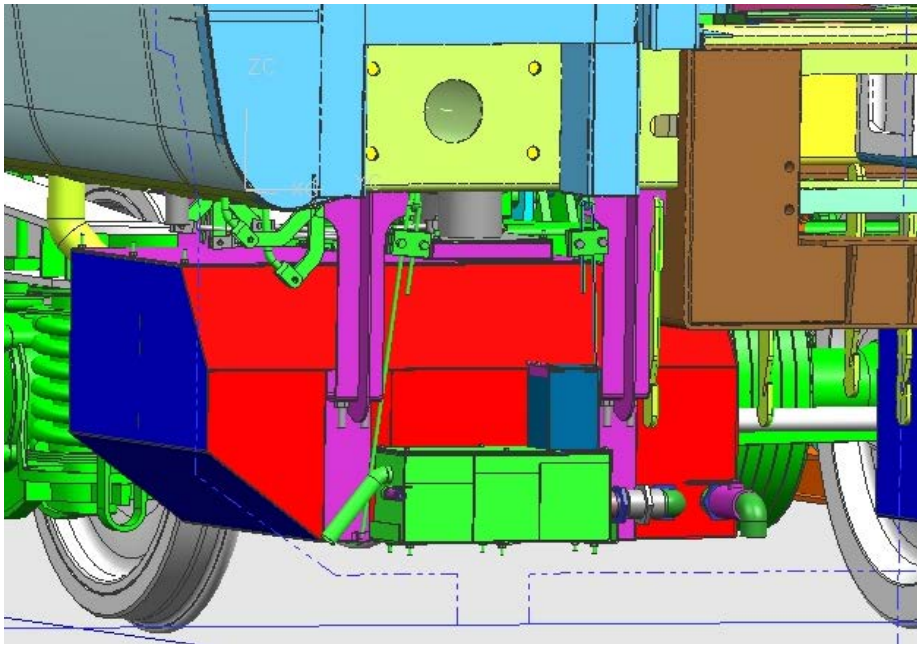
Alternate Design of bio-digester tank

Problem/Issues of old design Bio digesters have been eliminated.

Re- location of chlorinator.



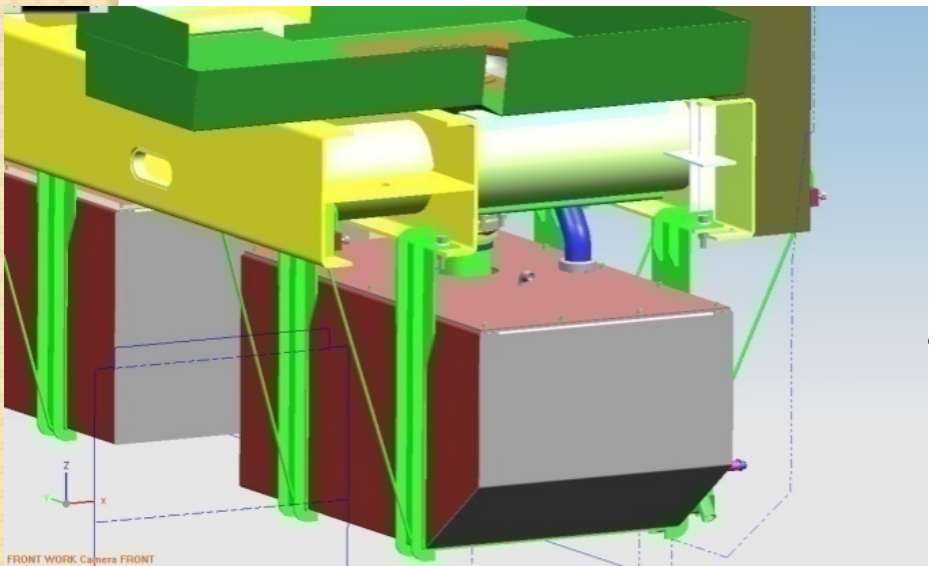
Smaller chlorinator- discharge at the center of track

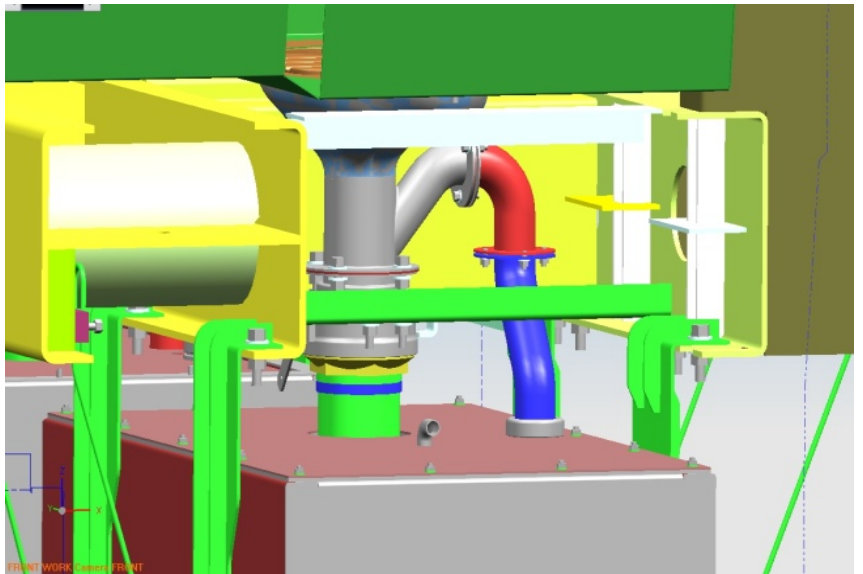


Bigger chlorinator-discharge on side of track

Design variants of bio-digester

- **3rd Design for Retro-fitment:**
  - **Additional 8 holes of 18 mm dia required in stock channels.**
  - **Head stock channel already have**:
    - 4 holes of 27mm diameter for buffer mounting;
    - One hole of 127mm diameter for buffer plunger
    - Two elliptical hole of 60mm x 40mm for brake pipe.

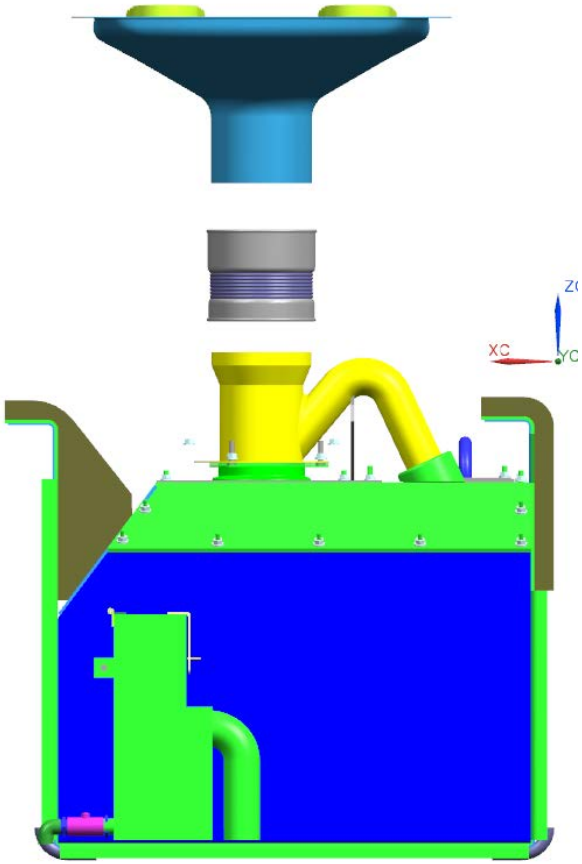




Improvements (between P-trap and pan)

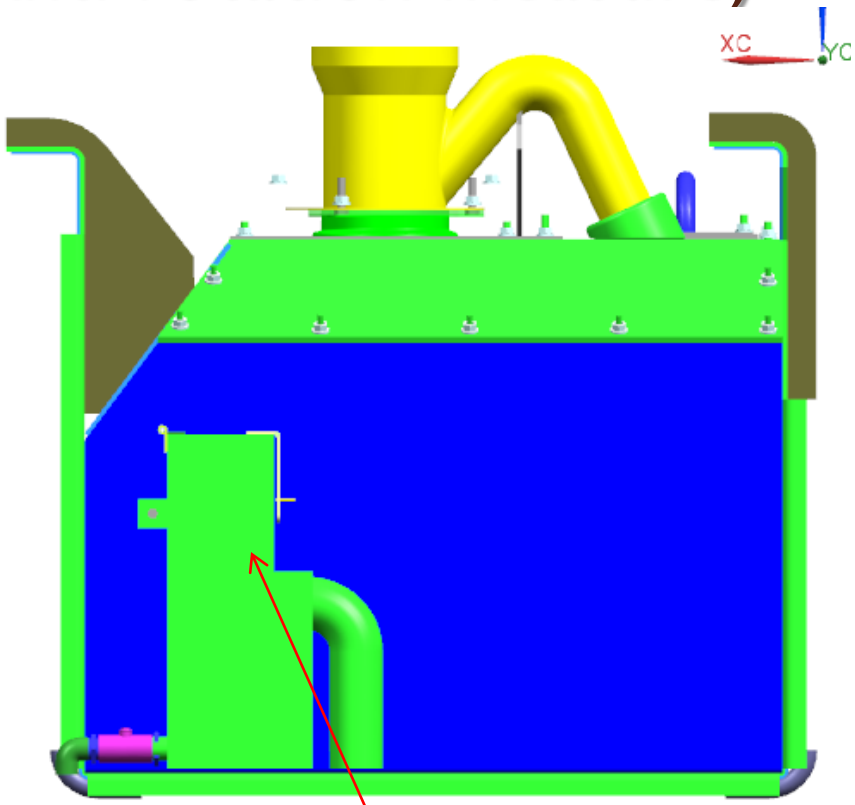
TPE Connector

Spread of fecal matter over tank



Connector between pan and P-trap

Improvements
(Modification of P-trap and Anti rotation measure)



Casted single piece

Anti rotation measure

Developments/Improvements (Development of KMnO4 Tablet)

- KMnO4 tablet development as an alternative of chlorine
- Evaluation/Validation by DRDE under final stages

$KMnO_4$ tablets

Chlorine tablets

Constraints in maintenance of Bio toilets

The following service problems are notice.

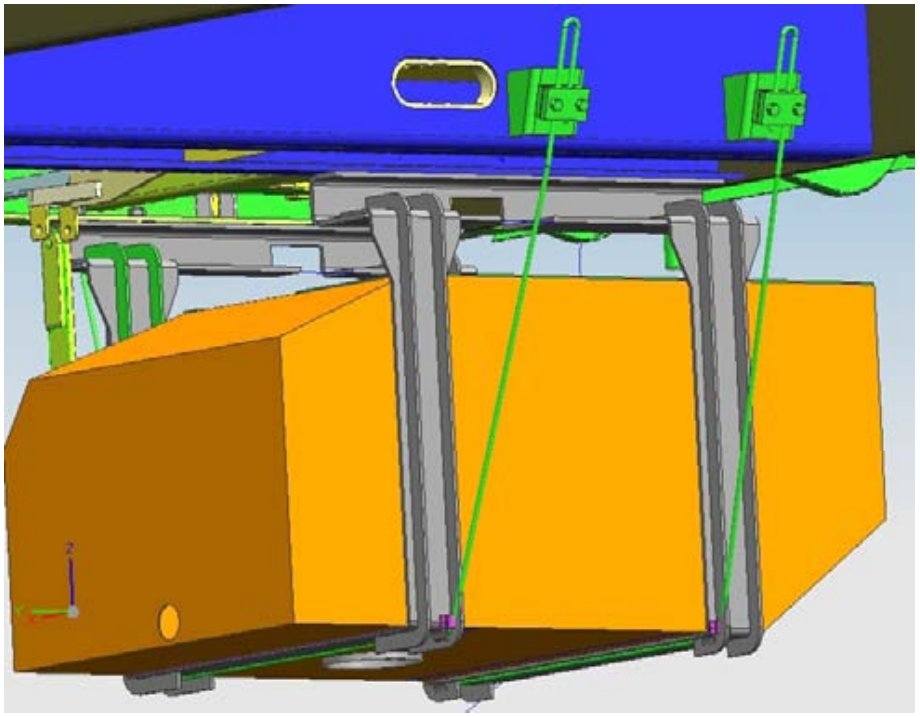
1. Due to in-adequate water being flushed by the passengers, the human excreta is not fully travelling from pan to the digester tank.
2. Ball values continue to be leaking and hence there is no water curtain, as a result, foul smell is coming from digester tank.
3. Hose connector between pan & P-Trap is getting torn while clearing the jammed / choked bio-toilet.
4. The ball value opening / closing mechanism is not easily workable even after applying full force by standing on the paddle to operate it.

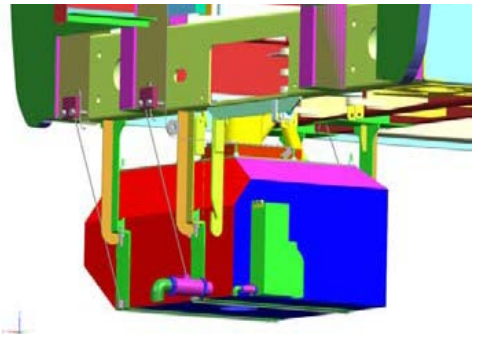
Vide: Lr.No.M.271/C&W/Green Toilets /Vol.II dt.11.08.14

South Central Railway has decided to replace connectors for all tanks during POH to overcome the problems in service.

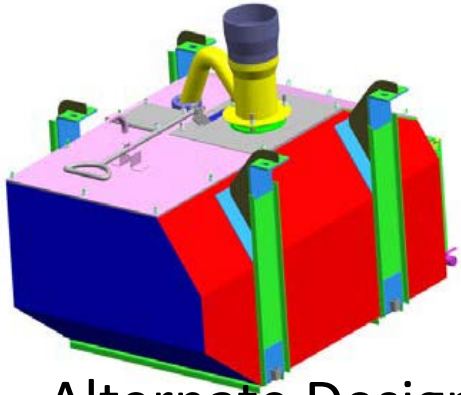
Alternate Design of bio-digester tank

For strengthening of the Bio digester tank, an alternate design has been developed by RCF and approved by RDSO in the month of May -2013. Alternate design finalised by RCF & RDSO for fitment-Positive
mounting with bolted fastening
The constructional features of the new design are shown as under:





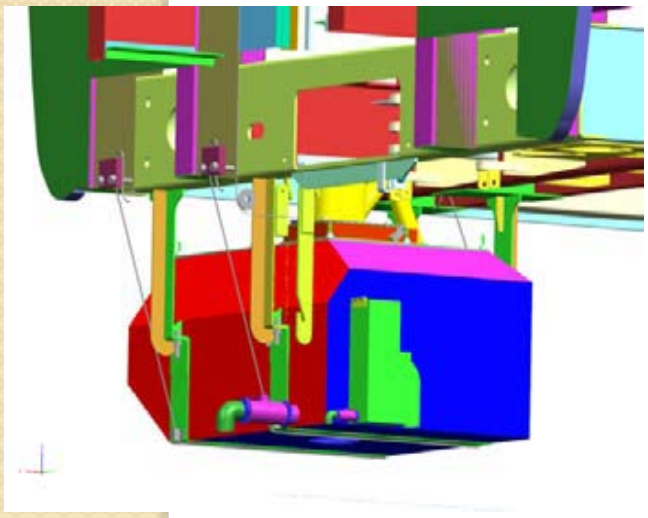
Existing Design



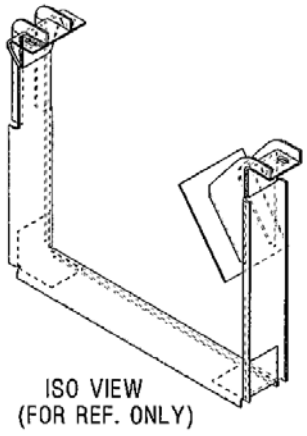
Alternate Design

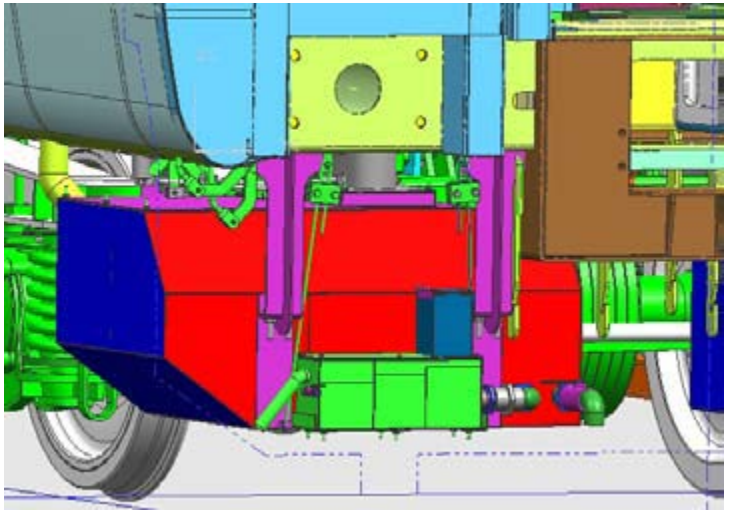
Alternate Design of bio-digester tank

- **Alternate Design of bio-digester tank**
- Problem/Issues of old design Bio digesters have been eliminated.
- In old design tank, too much welding in mounting brackets with tank.
- Possible infringement of hangers with bigger chlorinator, relocation of chlorinator.



Smaller chlorinator discharge at the center of track





Bigger chlorinator discharge on side of track

Efforts for public awareness

- Public awareness booths were setup at major stations as a part of 'Swacch Bharat Abhiyan'.
- Pamphlets and posters etc. Regarding bio toilet, were also published.
- An audio/video film was also played to create public awareness.

Public Awareness

Stickers in bio toilet coaches

To create awareness among passengers about use of bio toilet, stickers have been pasted inside bio-toilets and outside the coaches.

Public awareness

- Audio clips being played at major stations Video clips for running on electronic media.
- Press conferences to be organized for print and electronic media.
- Seminars to be organized in which print and electronic media was also invited to spread publicity among passengers.

Thank You