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Vacuum toilets for trains

On any regional or intercity train, the toilet system is an important part and the reliability of the system is critical. Without working toilets, the train cannot be put in service.

As the tank capacity for waste and fresh water is limited, the most suitable toilet for trains is the vacuum toilet, which only uses about 0.5 liter of water per flush. The common set-up for the on-board toilet system comprises a vacuum toilet module, which has all the required equipment to generate the vacuum, flush and empty the bowl, a holding tank for the waste and supplies for water, compressed air and electrical power.

The toilet module is mounted in a fibreglass shroud within the toilet cubicle and has quick connectors for the supplies of water, air and electricity and can easily be replaced in case of a malfunction or scheduled service.



Toilet Module (courtesy Glova Rail)

All the electrical equipment within the toilet module (solenoid valves, sensors) are connected to a dedicated toilet controller, which takes care of all the control and sequencing, required for the flush cycle of the toilet. In addition, the controller has built in monitoring and troubleshooting functions.

There might also be additional functions, such as monitoring of the supply air pressure and the level in the toilet bowl as well as levels in the fresh and waste water tanks.



Toilet Controller (courtesy Glova Rail)

Toilet module components

There are several different brands of vacuum toilets on the market and most of them have the same main components and work on the same principle.

Main components:

Ref on drawing	Description	Function
1	Toilet bowl	
2	Intermediate tank	To hold the waste during the flush cycle
3	Interface valve (inlet)	Will open briefly for the waste to be moved from the bowl to the intermediate tank
4	Interface valve (outlet)	Will open briefly to expel the waste from the intermediate tank to the holding tank.
5	Ejector	Generates the vacuum by a flow of compressed air
6	Pinch (hose) valve	Normally open, but closed when the intermediate tank is pressurised
7	Pressure/vacuum transmitter	Senses the pressure or vacuum in the intermediate tank.
8	Water pressuriser	Amplifies the water pressure to generate enough flow through the flush nozzles to clean the toilet bowl
9	Flush valve	Is activated when the bowl is flushed with fresh water
10	Check valve	To prevent water flowing back to the water supply during the flush
11	Flush nozzles	Direct and spread the flush water evenly around the toilet bowl
12	Air filter/regulator	Cleans and regulates the air to nominated working pressure for the toilet
13	Reed switch	Mounted on the inlet valve's air cylinder, will prevent the intermediate tank to be pressurized in case the inlet valve is open for any reason
Y1	Solenoid valve	To generate air flow through the ejector for vacuum to be generated in the intermediate tank. If the pinch valve (6) is closed, it will instead create a positive pressure in the intermediate tank.

Y2	Solenoid valve	Will close the pinch valve when active
Y3	Solenoid valve	Control of the inlet valve
Y4	Solenoid valve	Control of the outlet valve
Y5	Solenoid valve	Activates the flush valve and the water pressurizer



Interface valves (courtesy Glova Rail)



Water pressurizer (courtesy Glova Rail)



Pinch valve (courtesy Glova Rail)

Flush cycle

This is a brief description what happens after the flush push button has been pressed to start a flush cycle. The flush cycle sequence is managed by the toilet controller.

Initially, the bowl is rinsed with fresh water by solenoid valve Y5 activating the flush valve (9) and the water pressuriser (8). Both the inlet and outlet valves are closed at this stage.

Vacuum is generated in the intermediate tank by activating Y1 and letting compressed air flow through the ejector. It takes about 5seconds before sufficient vacuum has been achieved. The pressure or vacuum in the intermediate tank is monitored continuously by the pressure/vacuum transmitter.

At the end of the vacuum generating cycle and if the controller accepts that there is sufficient vacuum in the intermediate tank, the inlet valve (3) opens briefly by activating solenoid valve Y3 and the waste is moved into the intermediate tank.

After the inlet valve has closed and checked by the reed switch (13), the pinch valve (6) is closed by activating Y2 and compressed air is fed into the intermediate tank. When sufficient pressure is achieved, the outlet valve (4) is opened by its solenoid valve (Y4) and the waste is pushed out of the toilet into the holding tank.

A second flush is done at the end of the flush cycle to leave some water in the bowl.

Toilet controller

In addition to control the normal flush cycle, the toilet controller will also detect a number of fault conditions, such as:

- Faulty pressure/vacuum transmitter
- Inlet valve not closed when ordered
- Low vacuum during the flush cycle

and take appropriate actions.

The controller will also store fault data, as well as how many flush cycles the toilet has done. This data can be viewed or downloaded.

To assist with troubleshooting of the toilet system, the value of sensors and switches can be viewed on the controller and solenoid valves can be manually operated to simulate certain working scenarios.