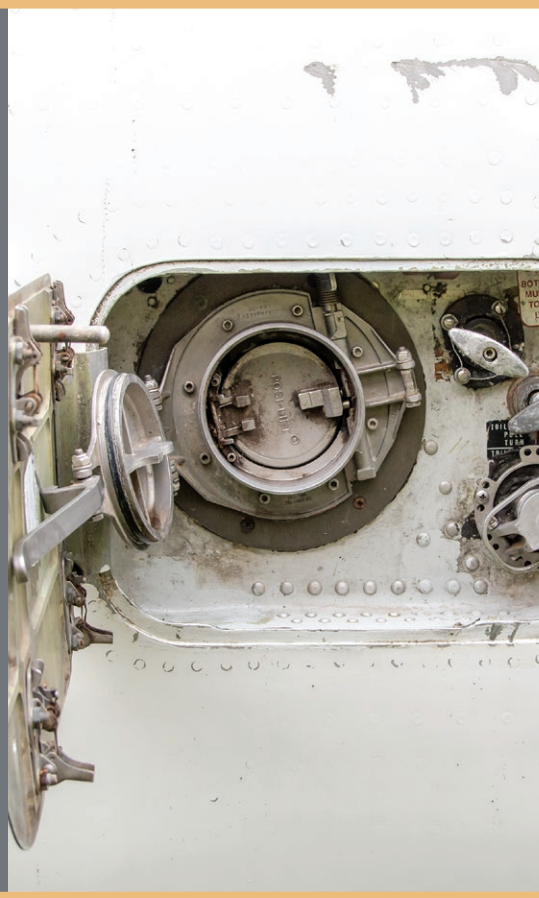

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Preface

Today's aircraft can fly long times and distances. Fortunately, they also provide for the comfort of the crew and passengers with sophisticated potable water and lavatory waste systems. This short publication gives some background and history before detailing the system components, how they operate, inspection requirements, and how to service the systems.

Publications, by their nature, must be general in their coverage of a subject area. The aircraft manufacturer is the sole source of operation, maintenance, repair, and overhaul information. The manufacturers' manuals are approved by the FAA and must always be followed. You may not use any material presented in this publication as a manual for actual operation, maintenance, or repairs of certified aircraft.

The authors and others who contributed to this textbook have done so in the spirit of cooperation for the good of the industry. To the best of their abilities, they have tried to present the material with accuracy, honesty, and pertinence. As with all human endeavors, errors and omissions can show up in the most unexpected places. If any exist, they are unintentional. Please bring them to our attention. ➙

To make comments or suggestions, email us at comments@avotek.com.

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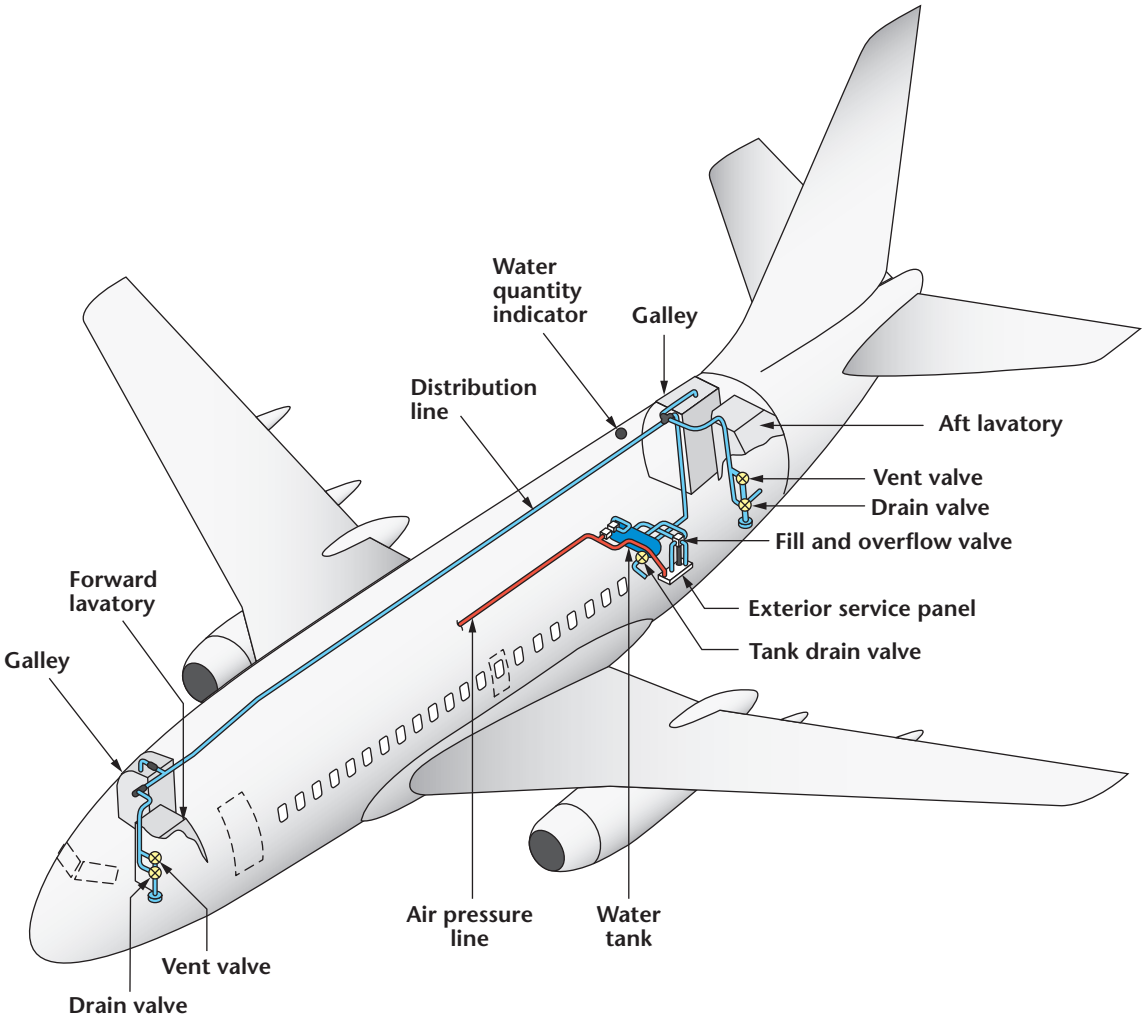

Figure 1. Location of the potable water system components on transport category aircraft.

Aircraft Water and Waste Systems

Section 1

Potable Water Systems

Humans need water to live. Many aircraft have systems to provide potable water for consumption and washing. The water goes to the galley and to the lavatories for the sink and toilet. These systems are primarily in transport category aircraft, although some business jets also have them.

System Components

Onboard storage tanks hold the potable water. The aircraft's pneumatic system, or a dedicated compressor, is used to pressurize these tanks. This pressure forces water through the distribution lines to the galleys and lavatories. The distribution lines are located overhead in the cabin or below the cabin floor. Service panels are provided and are used to control the fill and drain functions of the potable water system. Figure 1 shows where these components are on a large aircraft.

Storage

The potable water storage tank or multiple tanks are located below deck, behind the cargo compartment. The tanks are typically made from fiberglass-reinforced plastic and

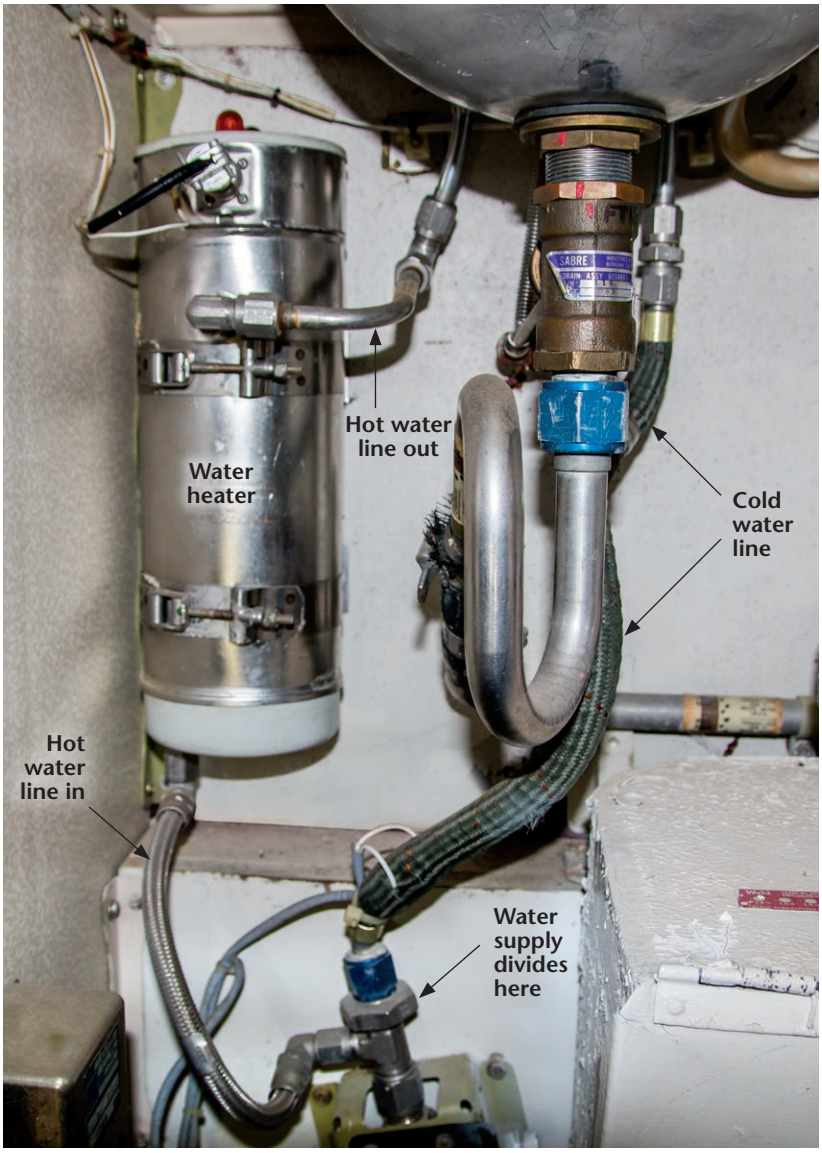

Figure 2. Under the lavatory sink, the lines lead to the cold faucet and to the hot faucet via the water heater.

can withstand from 25 to 45 p.s.i. pneumatic pressure, depending on the aircraft. The tanks have a standpipe to prevent overfilling, access panels, shear pin fittings, tie rod holes, a pressure connection, water fill connection, level sensor, overflow connection, rotation support hole, and distribution and drain connections.

Distribution

The distribution system includes lines that deliver water from the service panels to the storage tanks. The main distribution lines then deliver the water from the storage tanks to the galley and lavatories. They go from the storage tanks up to the aft passenger cabin ceiling, then forward above the ceiling panels or below deck to the lavatories and galleys. In the lavatories, the line splits for the cold-water faucet and to the water heater for the hot faucet (Figure 2).

A water supply shutoff valve is provided to allow technicians to stop water flow to the lavatory during maintenance. This valve is usually above the sink behind the mirror. The faucets provide hot and cold water and to the sink. These faucets are usually spring loaded to the off position to prevent wasting water. Each faucet has an adjustment screw that technicians can use to control how long the water flows from it (usually between 5 and 15 seconds).

Pressurization system

Connected to the water storage tank is a source of compressed air that supplies the water tank pressure. The pneumatic pressure is used to force the water from the tank and through the distribution lines to the lavatories and galley. A compressor, pump, or pneumatic supply from aircraft engine bleed air, the APU, or a pneumatic ground cart provide this pressure. Components of the system include a pressure regulator, limit switch, compressor interlock switch, relief valve, inlet air filter, and a drain valve (for removing water from the line from the compressor). If the pneumatic system pressure is not sufficient, the compressor is activated.

Filling system

The service panel is usually located in the aft fuselage. Larger aircraft could also have a panel in the front fuselage. Some aircraft use a UV treatment system to prevent organisms from entering the system. Ground service carts are used to fill the tanks. The service panels have a preselect switch and valve so that service personnel can set a quantity to fill, begin filling the tanks, and the valve will stop the water flow when the selected quantity is reached. The service panels also house system drain valve handles so the tank and distribution system can be emptied, if needed, for service or inspection.

Water quantity indication

The storage tanks have an internal water quantity sensor (capacitance type or a float). These connect to a transmitter that sends a quantity signal to an indicator in the flight deck and usually a gauge at the service or attendant's panel. Larger aircraft have multiple tanks, and a computer system calculates the total amount of water available. This information is shown on the crew alert system.

In the lavatories, water heating is provided via an electrical water heater below the sink

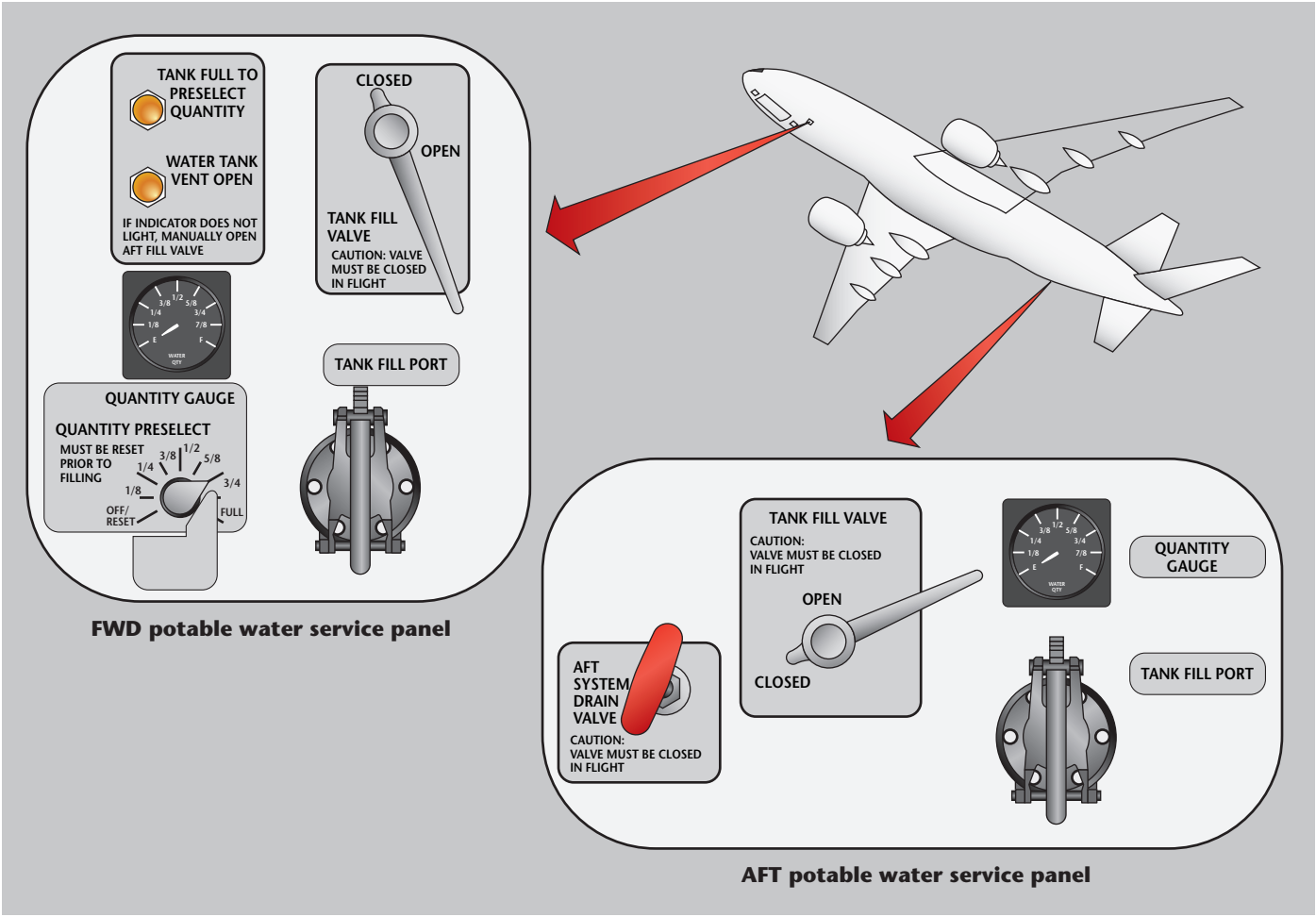

Figure 3. The exterior potable water service panels and their locations on a large aircraft.

(as shown earlier in Figure 2). A water filter removes particles from the cold water before it goes to the faucet.

Servicing the Potable System

The potable water system consists of components and subsystems for filling the tank, pressurizing the tank, distributing the water to the galleys and lavatories, monitoring the quantity of water in the tank, and draining the tank and distribution system.

Tank service components

An exterior water service panel (Figure 3) houses the connections and controls to service the tank.

- A fill connector and line connect the ground service cart with the potable water supply to the tank.
- An overflow outlet and line allow the crew to visually see if the tank is full. This outlet fitting is always uncapped.
- An air valve that can be used to pressurize the tank from a ground air source during service work.
- A drain valve control handle that controls the tank drain valve.
- A fill and overflow valve control handle controls the fill and overflow valve. When this handle is moved to the closed position, the following occurs:
  - The valve closes off lines to the service panel connectors and prevents tank air pressure from escaping.
  - The control handle moves to a position to allow the service panel access door to be closed.
- When the valve handle is moved to the open position, the following occurs:
  - The valve opens lines so water can flow through fill line to fill the tank and any overflow of air or water out of the tank through the overflow outlet.
  - The control handle moves to a position that does not allow the service access panel access door to close.

Tank filling procedure

To fill (or service) the potable water tank, the procedure listed below is typical and provided as an example. The crew must follow the manufacturer's instructions for the aircraft rather than these instructions.

1. Connect the potable water service cart to the fill connector.
2. Move the fill and overflow control handle to open.
3. Pump the water supply into the tank from the ground cart.
4. As water fills the tank, air in the tank exhausts out the overflow outlet. When the water level in the tank reaches the bottom of the overflow line standpipe in the tank, no air can exhaust. Only water pushes out the overflow outlet. This is a visual indication to the ground crew that the tank is full.
5. Move the fill and overflow control handle to closed.

Pressurizing the tank

The air pressure usually comes from engine bleed air. If the engine is not running, the pneumatic manifold supplies the pressure. This compressed air passes through a filter, a pressure regulator (reducing it to 25 p.s.i.), a pressure relief valve (opens at 50 p.s.i. and resets at 37 p.s.i.), and an inline check valve that prevents any water from flowing back into the air line.

Distributing the water to the galleys and lavatories

The water distribution lines go from the water storage tank, up and above the cabin ceiling to the galley and lavatories. The lines are flexible tubing enclosed in an aluminum shroud (essentially, a tube). The shroud protects the line, prevents leaks from reaching the cabin ceiling, and moves leaking water to the bottom of the fuselage for drainage.

Monitoring the quantity of water in the tank

A quantity indicator allows the ground crew to monitor the amount of water stored. The indicator is on the attendant panel over the right forward service door. The transmitter is in the storage tank.

Draining the tank and distribution lines

A two-position drain valve is below the tank for draining it and the distribution line above the ceiling. Normally, this valve is closed to shut it off. During draining operation, the technician moves this valve to the open position. The control handle for the valve is in the exterior water service panel. In the open position, the water in the tank and in the main distribution line drain out through an opening in the lower fuselage skin onto the ground. When the control handle is in the open position, it prevents the water service panel door from closing.

The lavatory distribution lines are drained through the drain valves in the lavatories as follows. The drain valve has three positions:

- **On**. The normal position allows water from the main distribution line to pass through to the heater and cold-water faucet.
- **Drain**. This is the position for draining the system. This allows water from the lavatory lines to drain overboard. Water passes through a drain outlet fitting in the lower fuselage skin under the lavatory. Water from the main distribution line in the cabin ceiling area also drains out of this valve.
- **Off.** This is the position for shutting off water supply from the main distribution line to the lavatory components. It is used during maintenance work, such as replacing the water heater or a faucet.

The lavatory faucets are the self-venting type, to allow lines to drain.

Section 2

Waste Systems

As aircraft developed the reliability and fuel efficiency to travel longer distances without stopping, it was quickly discovered that the range of the aircraft can exceed the range of human nature. This became very apparent to the military with large bombers and long flight times. Some provision had to be made for the comfort of the flight crew. This need has grown into the sophisticated water and waste systems found on today's transport category aircraft.

Figure 4. This relief tube is stowed under the pilot seat (top) and can be extended for relief (middle). The liquid exits via the venturi (bottom).

Small Aircraft Systems

Older, small aircraft can incorporate a relief tube system that the pilot can use to urinate during flight. The next step up can be found on today's small business aircraft that have a canister system that collects the waste. To empty the canister, the service crew must remove it from the aircraft, empty it, and replace it.

Relief tube system

The relief tube is used in some military and older civilian aircraft. It is probably the simplest system and consists of a receiver tube stowed in the flight deck under the pilot seat, or in the lavatory (Figure 4). The tube can be removed from its holder and allows a person to relieve oneself in it. The liquid flows down the tube and exits to the atmosphere via a venturi.

Figure 5. The canister can be removed for servicing.

Canister system

Another simple system used in small aircraft is the canister system. It stores waste in a container below a toilet seat. Ground crews empty the canister, clean it, and return it to the aircraft (Figure 5).

This idea dates to the 1940s. In World War II, large bomber aircraft, such as the American B-17 Flying Fortress and the British Avro Lancaster, carried what was referred to as chemical toilets. They were basically a bucket with seat and cover. In British use, they were called *Elsans* after the company that manufactured them (Figure 6). However, depending on crew size and the length of the mission, these often overflowed, and were difficult to use. Today's onboard systems are a major improvement.

Figure 6. Elsans were used to store waste in World War II-era British aircraft.
Courtesy of Bomber Command Museum of Canada

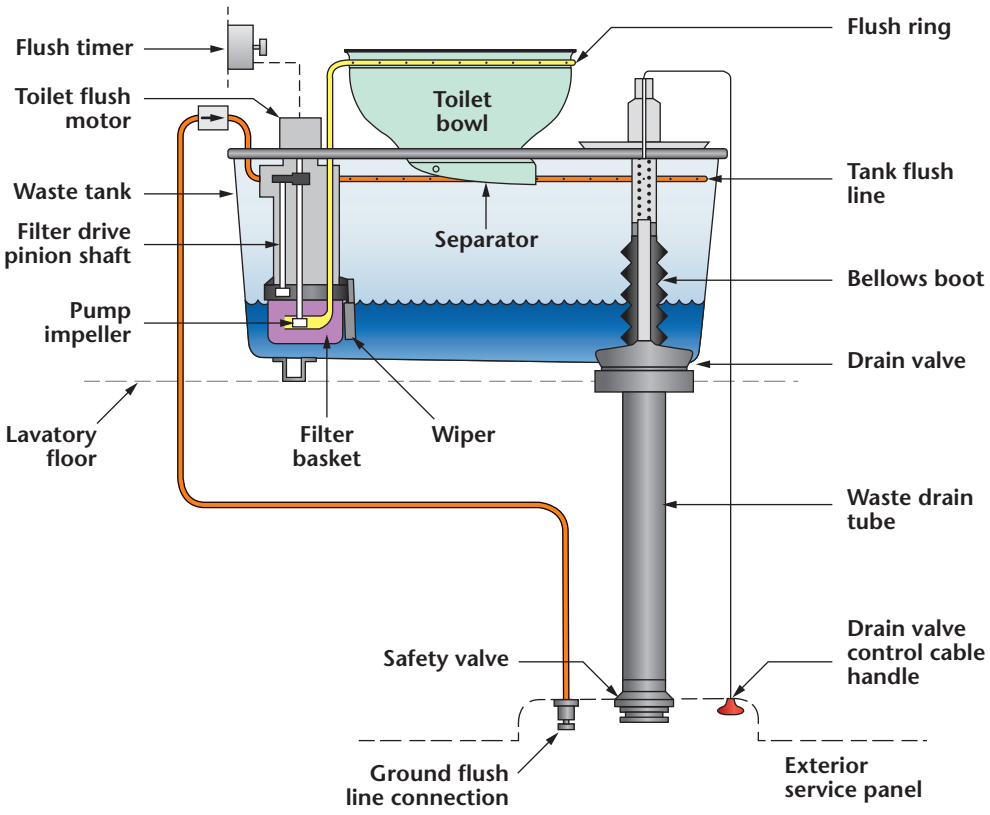

Figure 7. Schematic of a toilet on a 737.

Large Aircraft Waste Systems

Today's transport category aircraft use a much more sophisticated waste system. The waste system handles wastewater from the lavatory toilets, collecting it in below-deck tanks or the bottom portion of the toilet. The aircraft has service panels for crews to empty and clean the tanks. A second type of water that large aircraft might handle is gray water from galley and lavatory sinks. Gray water is water that is not clean enough to be potable, but it is not contaminated with dangerous matter such as waste from toilets. Gray water includes water used for washing or cleaning.

In large aircraft, the toilets receive waste and, when flushed using a vacuum system, deliver it to waste storage tanks. The system has monitors that signal the waste tank quantity information to flight and ground service crews. Ground service crew use service panels in the lower fuselage to empty the tanks and clean them.

Gray water drain system

Gray water systems used on some large aircraft, convey sink water from the lavatories and galleys, down through lines to a drain mast, where it exits to the atmosphere. In other large aircraft, the gray water flows to the wastewater storage tanks instead. A valve in the line prevents cabin air from continually leaking from the drain. The valve opens only when a certain amount of water has collected above it. Gravity and differential pressure between the cabin and the drain mast outlet (atmosphere pressure) move the water out through the drain mast. The drain mast is heated to prevent water from freezing and blocking the drain.

Vacuum waste system

The toilet waste tank can be located under a shroud in each lavatory in some aircraft, or, in larger aircraft, one or more waste tanks that collect waste from multiple toilets. In the shroud type of system, the shroud hides the tank and contains the toilet seat and its cover. Each waste tank consists of a fiberglass tank with a laminated stainless steel/fiberglass tank top. Fittings for flushing equipment, the toilet bowl, and a vent line are part of the tank top. Flushing equipment for the toilet bowl includes a flush handle, timer, motor and pump, filter, and related tubing (Figure 7).

Except the flush handle and timer, these items are attached to the top of the waste tank. The

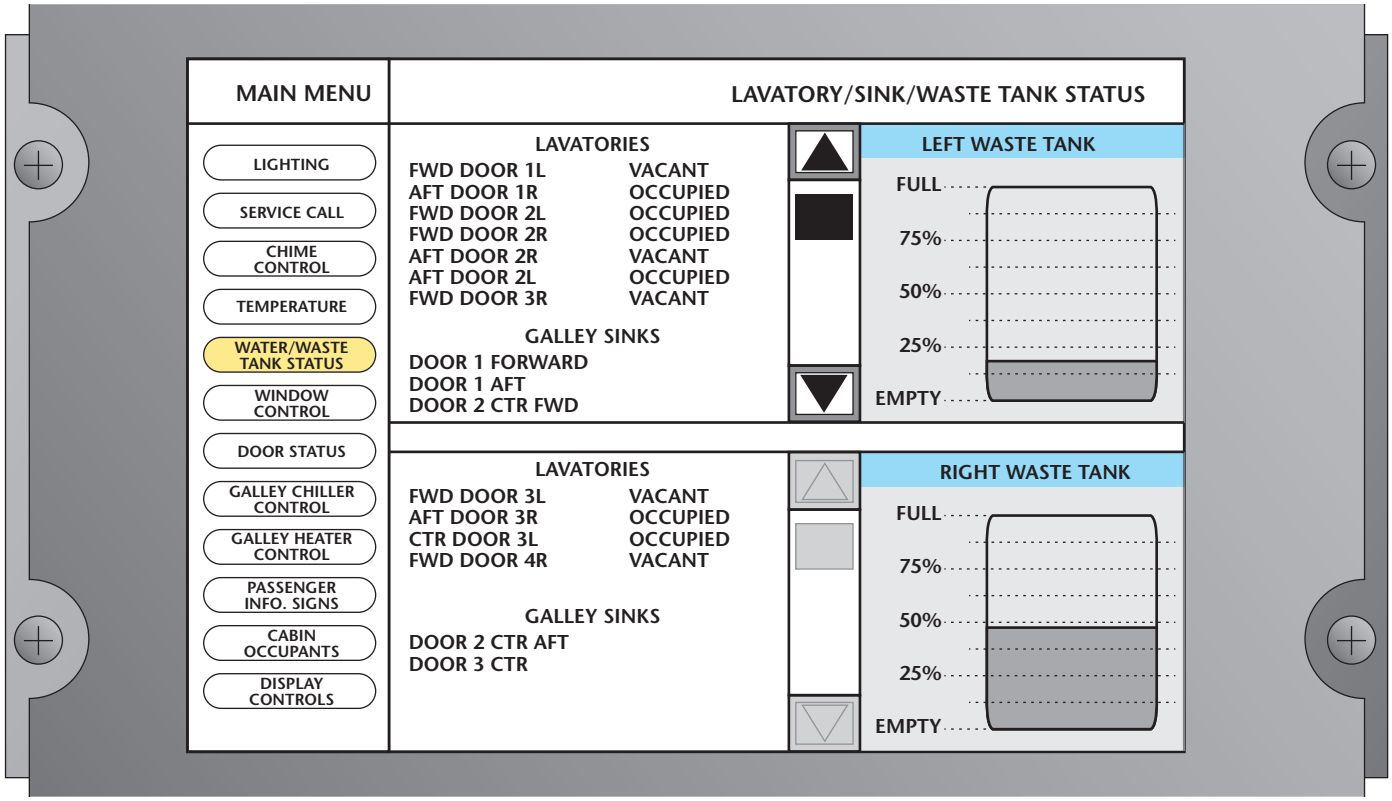

Figure 8. This cabin attendant panel displays lavatory status and waste tank quantities.

flush handle and timer are on the cabinet above the toilet. A stainless-steel toilet bowl is attached to the tank top. The bowl is fitted with a hinged separator between the bottom of the bowl and the tank. The waste tank has a perforated flush line inside it for washing out the tank during ground service work. The tank is held in position by three tiedown rods. It is positioned over a drain hole in the floor and connected via a line to an exterior waste service panel.

The toilet flushing motor is powered by a 115-volt, 3-phase AC supply. A reversing circuit in the flush circuit operates the motor in one direction for one flush and then reverses the motor rotation for the next flush cycle. When the flushing switch is pushed, a circuit is completed to energize a relay and provide power to the flush motor for the timed interval.

Wastewater tank quantity indication

The tanks have a sensor or sensors that transmit wastewater quantity levels to a controller or computer system. The crew can view the quantity of waste in the tanks using the flight deck or other cabin attendant information displays (Figure 8). If a tank is full, the transmitter signal is used to disable the toilets that flow to it and send a notice to the flight crew.

Waste service panels

The aircraft has separate exterior toilet service panels (Figure 9), one for the forward and one for the aft toilets. Both are on the right side of the fuselage. Each toilet service panel includes one 4-in. drain outlet, a ground flush line fitting, and a drain valve control cable handle for each waste tank. A 4-in. tube connects the waste tank to the toilet service panel. The toilet drain outlet is a standard Roylin plug assembly with a drain plug inside and a hinged cap on the outside. The hinged cap contains a lockout mechanism to prevent the cap from closing without the drain plug first being installed.

Initially, each toilet tank is filled with several gallons of a flushing solution made of water, deodorant, dye, and disinfectant. When the flush control is activated, the flush motor begins to rotate. It operates a pump in the tank that pumps the water into the bowl flush ring to clean and flush the bowl. At the same time, the motor drives a filter drive pinion shaft that rotates a filter basket. The basket surrounds the pump inlet to prevent large solid objects from entering the pump inlet. A fixed-wiper blade on the outside of the filter basket keeps the basket clean. A timer circuit in the flush circuit runs the motor for 10 seconds and then turns it off.

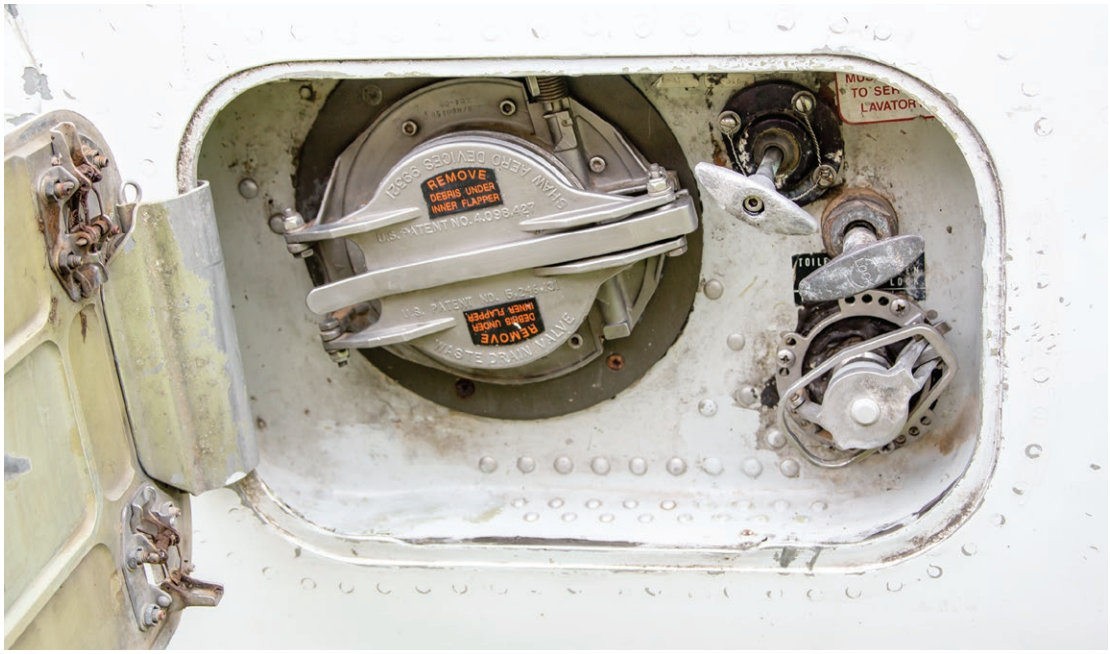

Figure 9. The lavatory service panel allows ground crews to empty the waste storage tanks.

A separator at the bottom of the toilet bowl hides the waste in the tank from the passenger's view. Flushing keeps the separator clean.

If the toilet flush circuit malfunctions, the cabin attendant pushes down the hinged separator in the toilet, so it is out of the way. When ground servicing, the crew must check the separator to see that it is up (the normal position). If it is not, the crew must check the flush operation and pull the separator back to normal. Replacing the toilet flush motor requires removing the motor, pump, and filter basket as a unit.

It probably goes without saying, but when servicing or performing any work on the lavatory waste system, be sure to use personal protective equipment (PPE). This includes such items as goggles and rubber gloves. The waste service panels are famous for leaking.

Servicing the Waste Systems

On some aircraft, each toilet tank must be drained, flushed with clean water, and then supplied with several gallons of the flushing solution. The procedure can vary for different aircraft, but below are typical steps provided as an example. The crew must follow the manufacturer's instructions for the aircraft.

1. The following PPE is recommended for workers handling human waste or sewage: Goggles to protect eyes from splashes of human waste or sewage. Protective face mask or splash-proof face shield to protect nose and mouth from splashes of human waste or sewage. Rubber gloves to avoid contact between skin and chemicals or waste products.
2. Connect the lavatory service cart drain hose to the exterior service panel drain fitting.
3. Pull the safety valve out of the drain fitting.

   NOTE: A special *Y* fitting is part of the ground equipment for this operation.

4. Pull the drain valve control cable handle to open the drain valve in the bottom of the toilet tank. Turn the handle to lock it in the open position.
5. After the toilet tank is completely drained, connect the water line to the ground flush line connection on the exterior service panel.
6. Flush the toilet tank with about 5 gallons of clean water from the ground cart.
7. Close the drain valve in the toilet tank by releasing the drain valve control cable handle.
8. Use the ground flush line connection to pump into the toilet tank 3 gallons of water with the flushing solution.
9. Reinstall the safety valve and the drain outlet cap.
10. Workers should wash hands with soap and water immediately after removing PPE.

Workbook Questions

To the Student

These workbook questions should be used as a tool for highlighting strengths and pinpointing weaknesses as you build a strong foundation of the various systems used in aircraft. Questions are divided into three formats:

Fill in the Blank: These questions are designed to help you understand new terminology and fundamental facts essential to understanding the chapter material.

Multiple Choice: These questions offer a broader overview of the material by offering several possible answers and allowing you to identify the correct answer, either through recognition or through the process of elimination.

Analysis: These are complex questions that require you to access information presented in the text, analyze the data, and record a response.

The answers for the questions are available from your course instructor.

Fill in the Blank

1. For potable water systems, the distribution lines are _____ or below the cabin floor.

2. A/An _____ is provided in the potable water storage tank to prevent overfilling.

3. _____ is what pushes the water from the water storage tank to the galleys and lavatories.

4. In a relief tube system, liquid flows down the tube and exits to the atmosphere via a/an _____.

5. A small aircraft wastewater system that uses a container below a toilet seat is called a/an _____ system.

Multiple Choice

1. On transport category aircraft, the water system can be pressurized from which of the following sources?
   a. Engine bleed air
   b. APU pneumatic air
   c. Pneumatic ground cart
   d. Any one of the above

2. Heated water at the lavatory sink usually comes from:
   a. A central water heater in the rear of the aircraft
   b. An electrical water heater under the sink, and connected only to that sink
   c. Heated water is not usually available at the lavatory sink
   d. A line from the galley sink

3. Potable water storage tanks have an internal quantity measuring system, and the amount of water available can be determined using visual indicator at:
   a. The water service panel
   b. On the Flight Engineer panel
   c. On the exit of the tank
   d. Under the sink in the forward lavatory

4. What is gray water?
   a. It is water that has been in the tank longer than seven days
   b. It is what is flushed down the toilet
   c. It is another name for potable water
   d. It is water that is not clean enough to be potable, but is not contaminated with waste from toilets

5. The toilet waste tank can be located:
   a. Under a shroud in each lavatory
   b. Under the sink in each lavatory
   c. One or more waste tanks can be connected to collect waste from multiple toilets
   d. Either A or C

6. When the toilet is flushed, the waste is directed to the waste tank using:
   a. High pressure bleed air
   b. High pressure water
   c. A vacuum system
   d. A gravity system

7. When servicing the toilet system each toilet tank is filled with:
   a. Grey water
   b. A flushing solution consisting of water, deodorant, dye, and disinfectant
   c. A flushing solution consisting of soap and water
   d. Potable water

8. The lavatory service cart drain hose removes the waste products:
   a. By dropping the hose down into each toilet on the aircraft and opening the suction valve
   b. By attaching to the aircraft's drain mast
   c. By attaching the hose to the fitting behind the lavatory service panel and pulling the drain valve control cable
   d. By parking the cart directly below the gravity tank drain and opening the exit valve.

Analysis

1. Describe how to fill the potable water system.

2. Explain what a shroud toilet system is and how it works.

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