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Recreation Vehicle Industry Association

Recreation Vehicle
RV Plumbing Systems

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Chapter

6-1 Introduction to RV Plumbing Systems

6-1.1 General

The plumbing system in a recreational vehicle (RV) is similar to the plumbing system in a house. The plumbing system's purpose is twofold: to supply potable water (both hot and cold) to a variety of fixtures (i.e., sinks, toilets, showers, and so forth) and to provide a means of disposing of the wastewater used at each fixture in a sanitary manner. This is accomplished through the use of two systems: a water distribution system to supply potable water to the fixtures and a drainage system to provide a means of sanitary removal of water and wastes from each fixture, and eventually from the RV.

Every RV plumbing system needs to be built in conformance with the *NFPA 1192 Standard for Recreational Vehicles* or *CSA Z240*. These standards specify the minimum criteria necessary for the safe installation of plumbing systems.

The plumbing system in an RV varies from that in a house in that both the water distribution and waste systems are usually self-contained (i.e., the RV owner has a source of water on board and an onboard means for storing waste when the RV is away from city water hookup or sewers). An onboard supply of potable water is stored in a potable water tank, and waste storage provisions are provided by one or more waste holding tanks.

6-1.2 Basic Plumbing System

This chapter provides an overview of the basic components and system designs that are commonly used by RV manufacturers in their plumbing systems. A glossary of plumbing terminology is provided at the end of this textbook, and an explanation of tools and test equipment for the plumbing system can be found in *Chapter 6-2*.

6-1.2.1 Drainage System

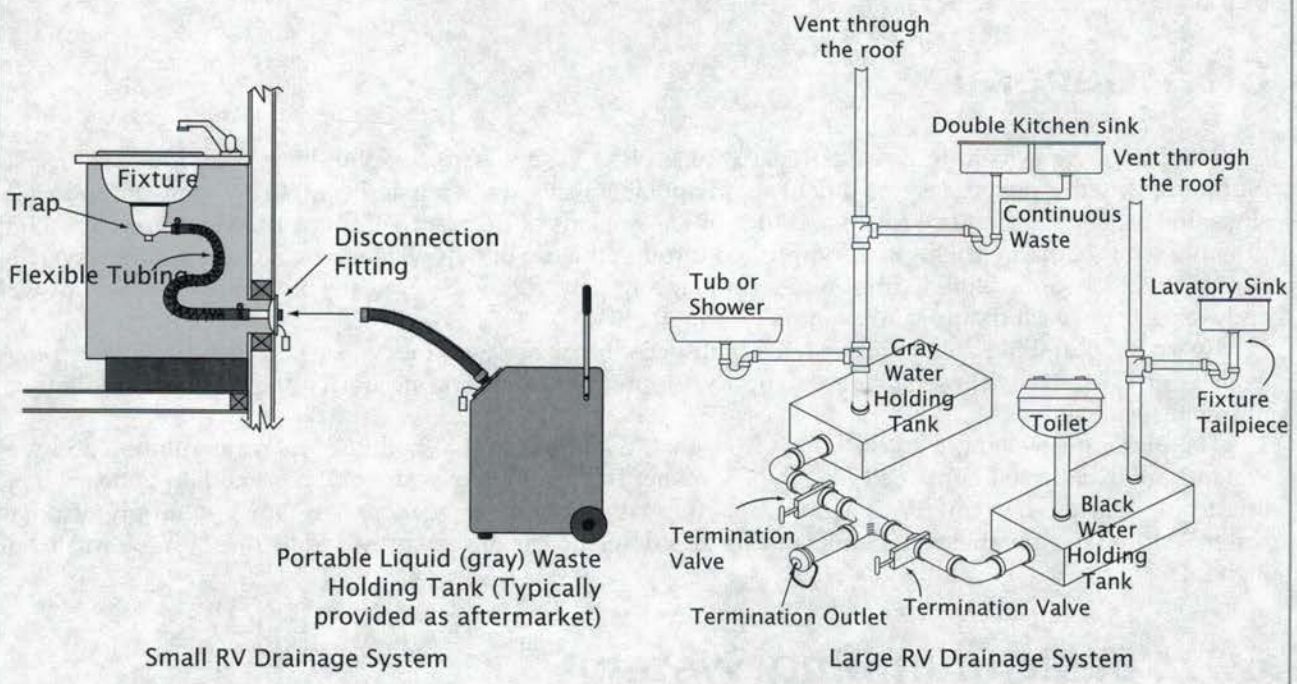
Figure 6-1 ABS Pipe Markings

The drainage system of an RV consists of a piping system to convey wastes and wastewater from the fixtures to the wastewater holding tanks or main drain outlet. This piping system commonly consists of plastic piping designed so the wastewater will drain by gravity through this piping from the fixtures to the waste holding tanks or main drain outlet. RVs usually use acrylonitrile butadiene styrene (ABS) pipe for the drain, waste, and vent (DWV) systems. ABS is used in the RV industry because it is impact resistant in cold temperatures. ABS DWV piping is typically black but can also be white. The type of material will be printed along the length of the pipe. Fittings have this information embossed into the plastic, normally on the body of the fittings, away from the hubs.

DWV piping is sized by the wall thickness of the pipe. The wall thickness is determined by the amount of pressure the pipe is capable of holding. The amount of pressure is typically listed in a "schedule," and the piping, therefore, carries a "schedule size." The ABS DWV in an RV is typically schedule 40 or equivalent. Thin-wall materials have been used in "continuous wastes" (the piping between the outlets of a two compartment sink and its P-trap), fixture tailpieces, and P-traps.

The diagrams in *Figure 6-2* show examples of some basic RV drainage systems. Note that some smaller RVs, such as folding camping trailers and truck campers, may not use onboard wastewater holding tanks but are set up for connection to a portable holding tank. Larger RVs typically use onboard holding tanks or can be connected directly to the sewer system in the RV park.

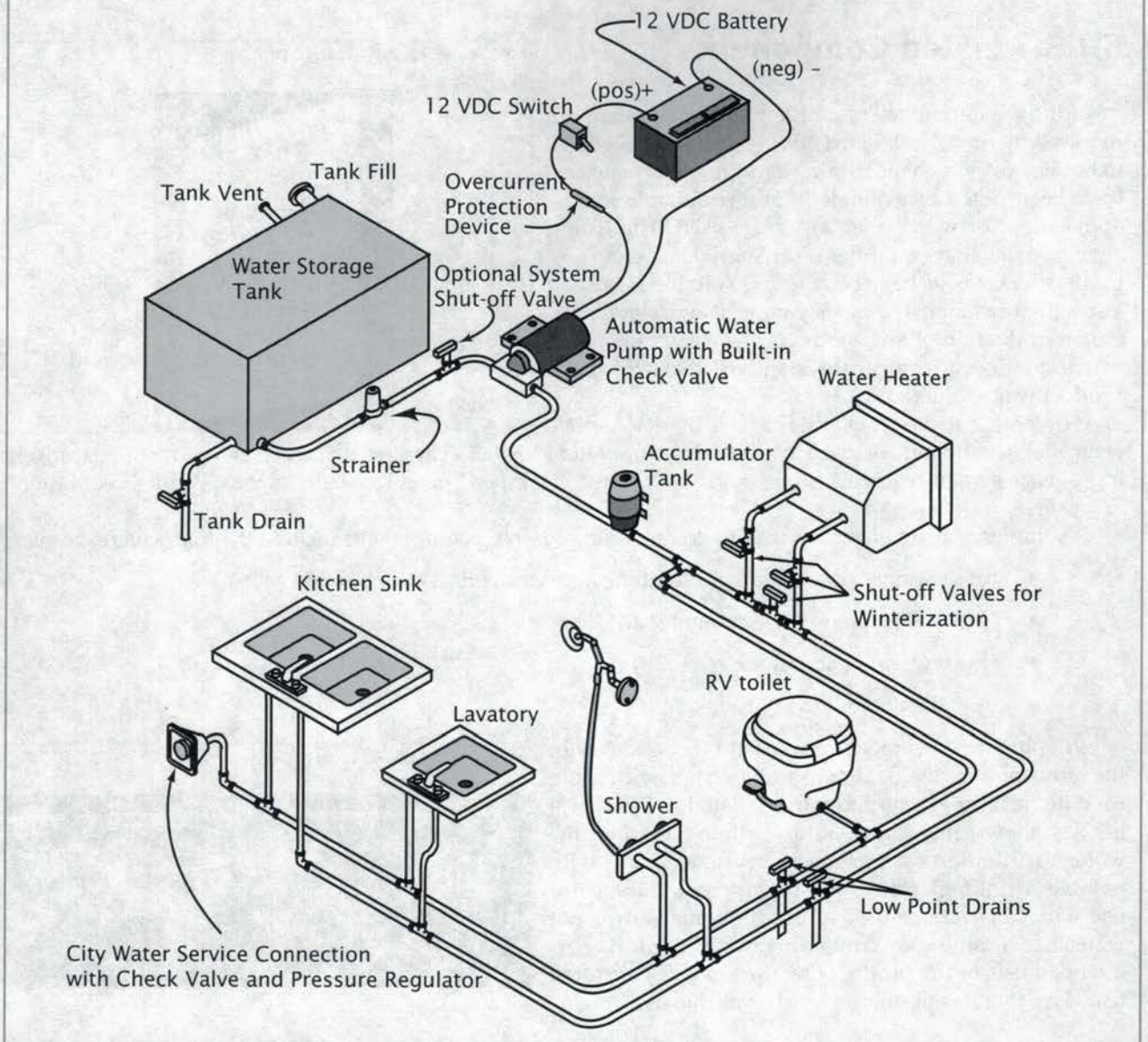
Figure 6-2 RV Drainage System Examples



6-1.2.2 Distribution System

The water distribution system of an RV may consist of the piping system, freshwater storage tank, water heater, water pump, faucets, and any other components used for conveying freshwater to the fixtures. *Figure 6-3* shows an example of a typical RV water distribution system.

Figure 6-3 RV Water Distribution System



This system also shows a system shutoff valve and system low point drains. The optional system shutoff valve will keep water in the storage tank in the event a repair is needed in the system. Turning this valve to the closed position will eliminate the need to drain the tank before repairs are made.

Low point drains are required to be in the system to allow the system to be drained by gravity. However, because of flexible water lines and multiple potentials for "low spots" within the system, the use of potable antifreeze or "blowing out" the system with compressed air should be considered when winterizing the RV.

6-1.3 Components of the RV Plumbing System

6-1.3.1 Listed Components

Figure 6-4 Listing Mark Example

All the components of an RV plumbing system are required by the RV standard *NFPA 1192* and *CSA Z240* to be "listed," which means that equipment or materials have been tested or evaluated and are suitable for the application for which they are to be used. The listing agency states that equipment or materials meet appropriate standards or have been found suitable for use in a specified manner. The agency must also provide periodic reevaluation of any product it has listed to ensure that it continues to meet the standards for which the product was evaluated.

For practical purposes, this means the RV service technician should ensure that any plumbing components installed are listed and can be so identified. Most listing agencies require their listing mark be printed, stamped, or embossed on the product, as shown in *Figure 6-4*.

Examples of listing agencies' marks common on plumbing components include the following examples:

- International Association of Plumbing and Mechanical Officials (IAPMO)
- National Sanitation Foundation (NSF)
- Underwriters Laboratories (UL)
- Canadian Standards Association (CSA)

Figure 6-5 DWV Listing Mark

All plumbing components must also be used within the terms of their listing. For example, all plastic piping used in the drainage system must be listed as DWV piping (as shown in *Figure 6-5*), and piping used in the water distribution system must be listed for use with potable (drinking) water. Plastic pipe and tubing for use with hot water must be listed specifically for hot water use. Piping may contain markings regarding its intended use, or the product literature can be consulted to ensure that it is permitted for the specific use.

6-1.3.2 Water Distribution System

6-1.3.2.1 General

RV water distribution systems need two things to function: a source of potable water and a means of providing pressure to force the potable water through the piping to the fixtures for use.

A source of freshwater is typically provided by one two methods. The first is to provide a potable water storage tank on board the RV, and the second is to provide a city water connection.

An onboard potable water storage tank, as shown in *Figure 6-6*, is one way of ensuring potable water is available for camping. These tanks are commonly polyethylene or a similar plastic and are built into the RV at the time of manufacture.

A city water service connection, as shown in *Figure 6-7*, allows the RV water distribution system to be connected to an outside source of water through a common garden-type hose. The garden-type hose used should be a high-quality hose suitable for potable water to ensure acceptable water taste. A city water service connection is commonly a 3/4 in. swivel female hose connection supplied on the RV exterior. Most RVs provide both these means of obtaining potable water.

Figure 6-6 Freshwater Tank

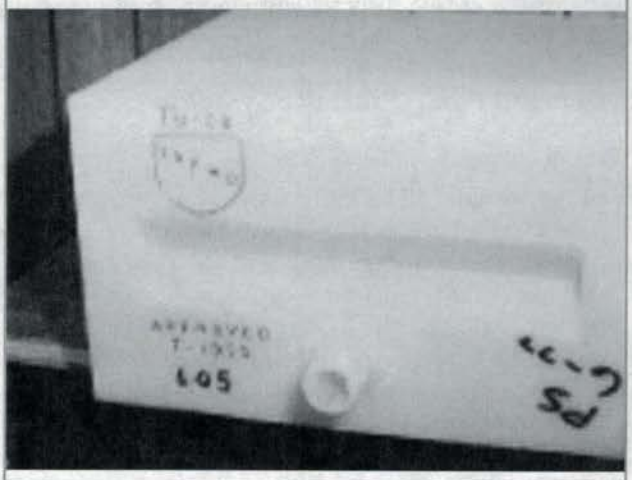
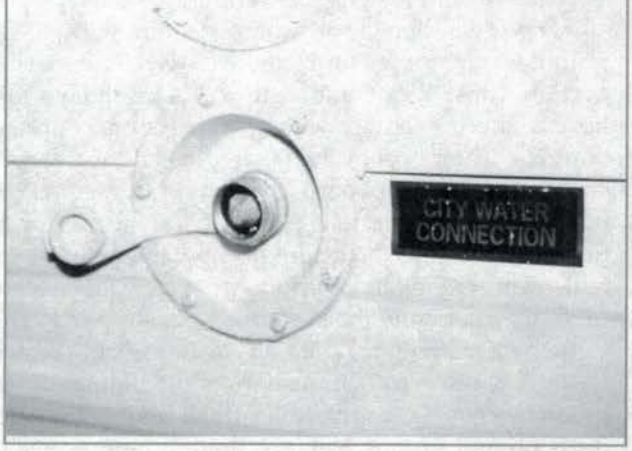


Figure 6-7 City Water Connection Label



NOTE: Be aware of the difference between city water inlet and a similar connection used for flushing holding tanks.

There are four ways to get pressure for the freshwater distribution system. These four methods can also be used to describe the type of water system:

1. City water pressure system
2. Demand pump pressure system
3. Manual pump system (creates own pressure)
4. Air pressure (older RVs)

To pressurize the water system on the RV, any of the four options above are available. Usually, only one or two are available in any one RV, but small units, such as folding camping trailers, may have all of the first three. The fourth kind of system uses an onboard air compressor to pressurize the system instead of a water pump. However, the "air pressure" system was more common to older units.

City Water Pressure System

This is a system that depends on the pressure created by the city, county, or well system in the park or community. This external pressurized water source is connected to the RV through a hose positioned between the source and the city water service connection (discussed previously) on the RV. The use of city water provides a constant source of pressure to the RV when it is hooked up.

The water hose, similar to the standard garden hose variety, should be marked for "potable" or "drinking" water. Some garden hoses are made from rubber and make water taste and smell bad.

To provide pressure to the RV water system when city water is not connected, other methods are commonly used. More than one system or source of pressure can be on the same RV.

If the RV is not equipped with a water pressure regulator, *Figure 6-8*, it is recommended (but not required) that one be used when using the city water connection.

Figure 6-8 Water Pressure Regulator

Demand Pump Pressure System

A demand pump pressure system uses an electric pump, usually 12 VDC, to move water through the system. The demand pump is located between the onboard potable water storage tank and the distribution piping system. A demand pump turns itself on by an internal switch that activates when the water system pressure decreases. The internal pressure switch shuts the pump off when pressure is reestablished. It has a pump motor that can usually be heard almost instantly as a faucet is opened. Opening a faucet will reduce the internal water system pressure, and this turns on the pump. *Figure 6-9* shows an example of a demand pump.

Figure 6-9 Demand Pump

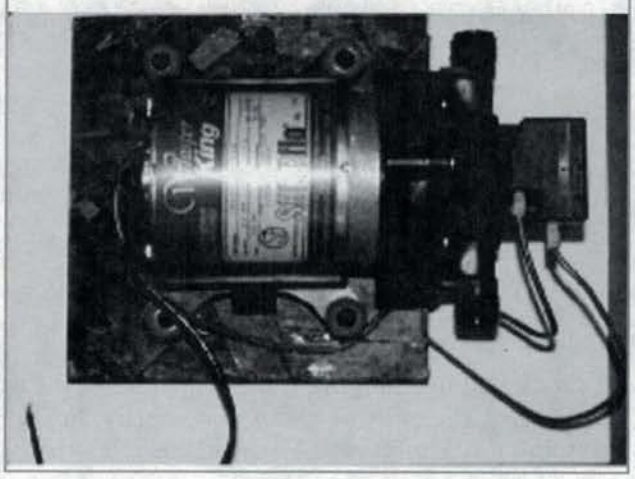


Figure 6-3 depicts a water system with a water pump, water storage tank, and a city water service connection. Most RVs come with a 3/4 in. female swivel hose connector for city water service connection with a nontoxic water hose. When using the city water service connection, the onboard system is protected by a built-in check valve that prevents the city water from flowing back into the pump and potable water storage tank. The city water supply provides the necessary pressure to operate the system and is supplied directly to the water system. When city water is not connected to the RV, the water pump senses the demand created by an opened faucet or toilet flush and automatically turns on and pumps water to the fixture that has been opened.

Demand pumps usually pressurize to about 40 to 50 psi, but are some pump pressures will be higher. But, on the other hand, city water pressure can be very high—sometimes as high as or higher than 100 psi. In order to ensure lower, constant water pressures in the RV, an external water pressure regulator can be added to the system. An external water pressure regulator attaches at the city water inlet or between the city water faucet and the supply hose to the RV. Water regulators will reduce high pressures to a constant pressure of about 45 psi, which corresponds with average pump pressures. Water distribution system components are tested and listed for operation up to 100 psi.

Manual Pump

Figure 6-10 Hand Pump

A hand pump can create pressure for delivering water to the fixtures by physically pumping its handle back and forth until the water is drawn to the fixture and the amount of water required is obtained. Certain models will use a small 12 VDC pump to pump the water. The water flow will be prevented if the manual pump is not in use. Some pumps require the handle to be locked in a certain position to hold the water in the water line to the pump. An example of a hand pump is shown in *Figure 6-10*.

Air Pressurized System

In an air pressurized system, shown in *Figure 6-11*, an onboard source of air (air compressor) or a means for a connection to an external air source, or both, are directly connected to a metal water tank capable of storing compressed air. The metal water storage tank is pressurized by the air compressor or external pressure source, and this pressure is then used to force the water into the distribution system when a faucet is turned on. These systems are not common in today's manufacturing of RVs.

Figure 6-11 Air Pressurized Water System

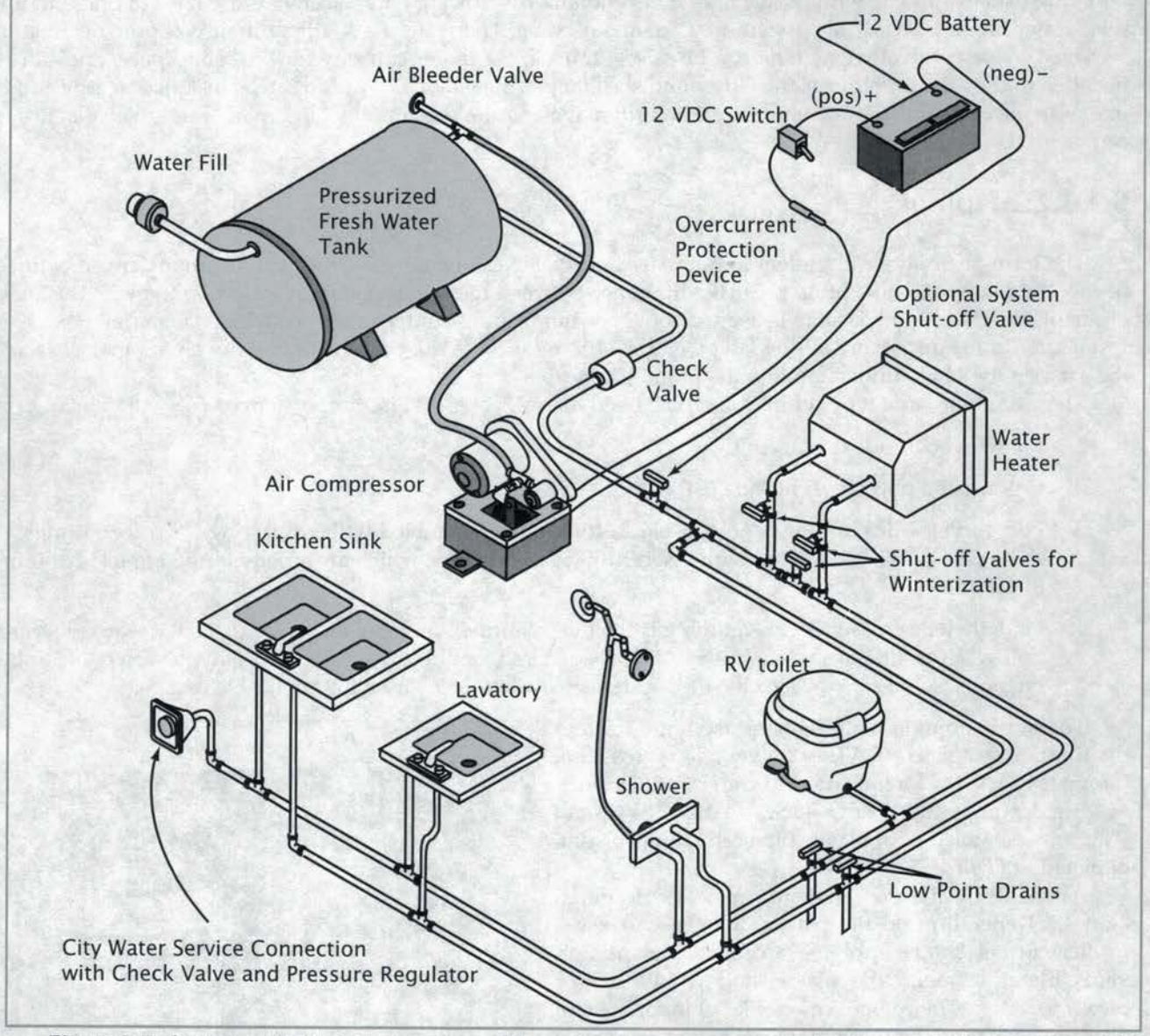


Figure 6-11 depicts a simple water system with an air compressor, pressurized water tank (usually metal), and a city water service connection. This system has a check valve to protect the air compressor and water tank when the city water supply is also connected to the RV and in use. When the city water supply is disconnected, the check valve allows water to flow from the potable water tank to the fixture. The air compressor will replace the need for a water pump in this type of system. The air compressor maintains a supply of air that enters from the top of the tank. When the faucet is opened, the air pressure will then force the water out. Because the supply of water from the tank to the RV water system is located at the bottom of the tank, the air pressure will

"push" the water out of the tank whenever a fixture is used, so as to place a demand on the system. The pressure created in the tank ensures the flow of water throughout the system.

An optional system shutoff valve can be installed into the system. This shutoff valve's purpose is to keep water and pressure in the tank just in case repairs need to be made in the system. Turning this valve to the closed position will eliminate the need to drain the tank before repairs are made.

Most air pressure system water fills have an air fitting included, either on the fill housing or built into the cap for pressurization from external sources. Care must be taken when removing the cap, because it could be under pressure. The air pressure in the tank must be bled out before the cap can be removed. The steel water tanks are usually "lined" with plastic but will eventually rust through. Replacements are hard to find, but it is relatively easy to convert this system to a "demand" type. The water tank, fill, and air compressor must be removed. A new polyethylene tank can be selected, usually a larger capacity for the same space, and can be installed in the same location as the old, round steel tank. A new demand pump can be installed nearby and in line with the outlet of the new tank. The water fill may need some adaptation, but many fills are available and can be used.

6-1.3.2.2 Piping

The term *piping* typically refers to both *pipe* and *tubing*. The manufacturing specifications are sometimes needed to distinguish the difference. The difference between the two is generally based on the wall thickness of the piping. The piping system is used to convey water from its source to the fixtures. Its material, type, size, installation, and support are addressed by *NFPA 1192* and *CSA Z240*. Understanding the piping materials and their uses will help in understanding the plumbing system.

There are four basic types of plastic piping used for RV water distribution systems:

1. Polyvinyl chloride (PVC).
2. Chlorinated polyvinyl chloride (CPVC).
3. Polybutylene (PB) tubing is grey or black, commonly assembled with crimp rings or screw fittings. In some cases, PB is assembled with insert fittings and clamps, which are strictly limited to inside piping installations.
4. Polyethylene cross-link (PEX) tubing is the most common material used in today's RV water distribution systems. PEX is a white/translucent opaque, red, or blue. This tubing employs a variety of joining methods, so refer to the specific PEX systems installations manual for applicable data.

Figure 6-12 Pipe Cement

The most common material now used in RV water distribution systems is CPVC or polyethylene cross-link tubing (PEX), listed for hot and cold water installations.

Rigid piping and fittings such as ABS, CPVC, and PVC are assembled with plastic pipe cement or solvent, depicted in *Figure 6-12*.

ABS, CPVC, and PVC solvents are not considered "glues." Depending on the plastic, it is best to use a primer cleaner before applying a cement sealant. Solvents literally "melt" the plastic and weld the two pieces together. The cement (more like glue) or solvent needs to be marked on the container that it is acceptable to use on the piping material being installed. Some solvents are listed only for use on specific materials. When joining different materials, such as ABS to PVC, be sure the cement is marked as acceptable for both materials. Otherwise, the connection may not stay together, especially with the vibration and jolting an RV undergoes while on the road.

Flexible piping such as PB is commonly assembled with crimp rings or screw fittings. Some PB is assembled with insert fittings and clamps. However, this joining system usually is limited to inside piping installa-

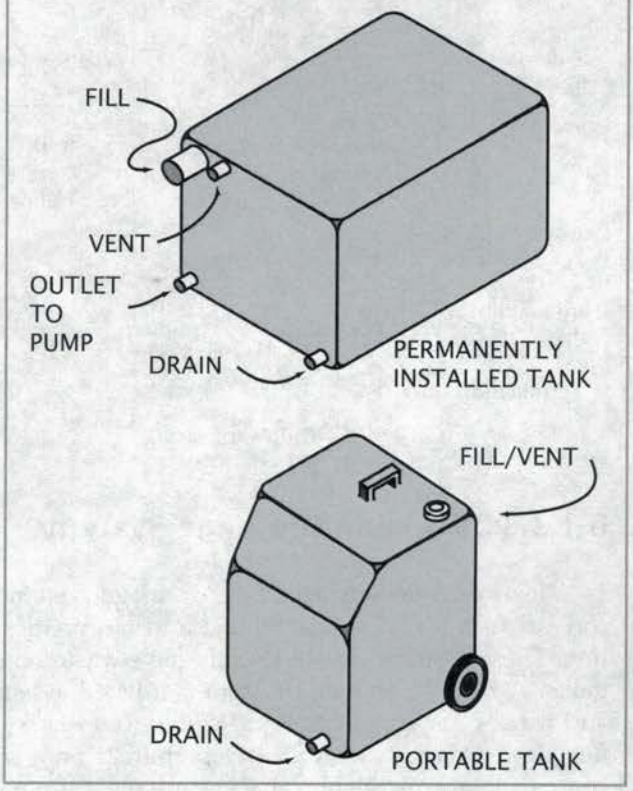
tions. PEX tubing can use a variety of joining methods, and the specific PEX systems installation manual should be consulted. Remember that any plastic piping used for the water distribution system must be listed.

Copper tubing may also be used as a material for water distribution systems in RVs. Copper tubing systems are not commonly used in many new RVs but can be found in some older or high-end (expensive) RVs.

6-1.3.2.3 Tanks

Freshwater storage tanks installed in RVs come in many shapes and sizes. These tanks range from large, permanently installed tanks to small, removable tanks as shown in *Figure 6-13*. Most RVs have permanently installed tanks capable of being filled from a water fill location on the side of the RV.

Figure 6-13 Potable Water Storage Tanks



6-1.3.3 Drainage System

6-1.3.3.1 General

Drainage systems in RVs are installed to ensure that wastewater can be safely transferred to the wastewater holding tanks or the sewer from the main drain. The drainage system is made up of the fixture tailpieces or continuous wastes, the P-traps, piping, fittings, vents, and termination fittings and valves. For the most part, the material for all these items will consist of ABS plastic. Every water system must have drainage capability for wastewater. *Figure 6-14* depicts a typical drainage system. The liquid waste holding tank is commonly called a *gray water* holding tank and collects the water coming from the shower and faucets of the system. The body waste holding tank is commonly called the *black water* holding tank and collects the wastewater from the toilet(s).

Figure 6-15 depicts an entire drainage system as it would look on a typical travel trailer. Drainage system specifications are contained in *NFPA 1192* and *CSA Z240*. *Figure 6-15* also depicts some of the traps and vents that are required by *NFPA 1192* and *CSA Z240*. Notice how the termination outlet and the single outlet (main drain) service both the gray water and black water holding tanks. This outlet is used to drain the holding tanks when connected to a dump station or when connected to an external sewage system. Consult the owner's manual for the proper procedures for draining the holding tanks. Typically, several flushes are required to properly drain and cleanse the holding tanks.

Figure 6-14 Typical Drainage System

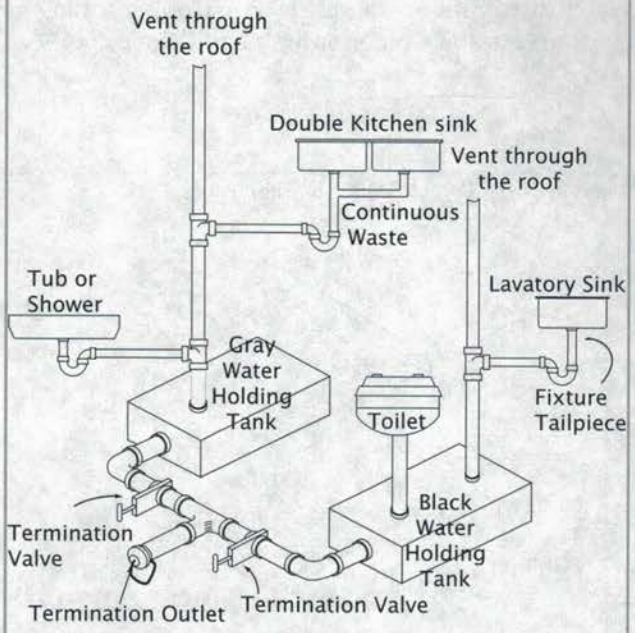
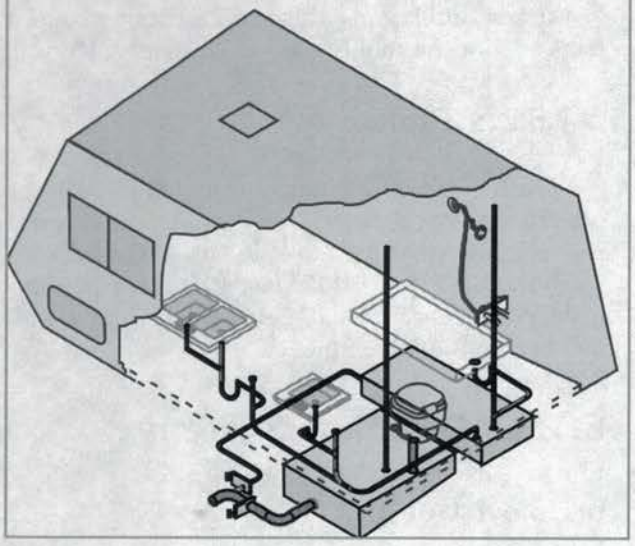


Figure 6-15 Drainage System on Typical Trailer



6-1.3.3.2 Flexible Drainage System

Figure 6-16 Flexible Drainage System Piping

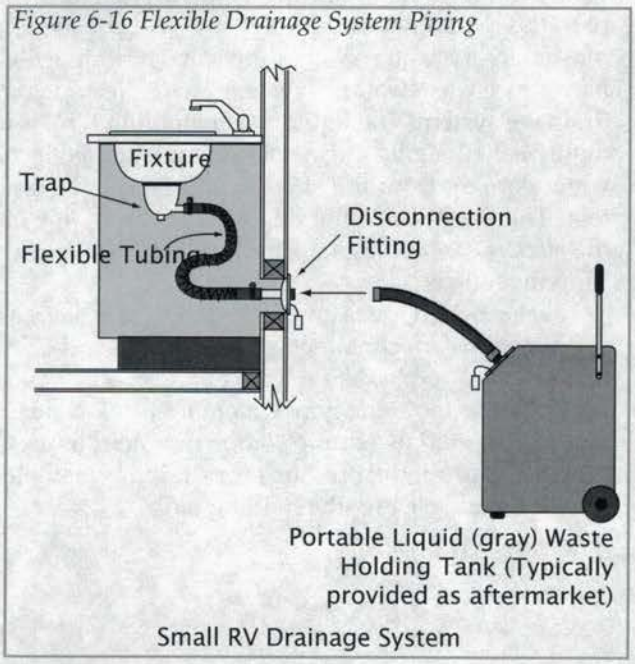


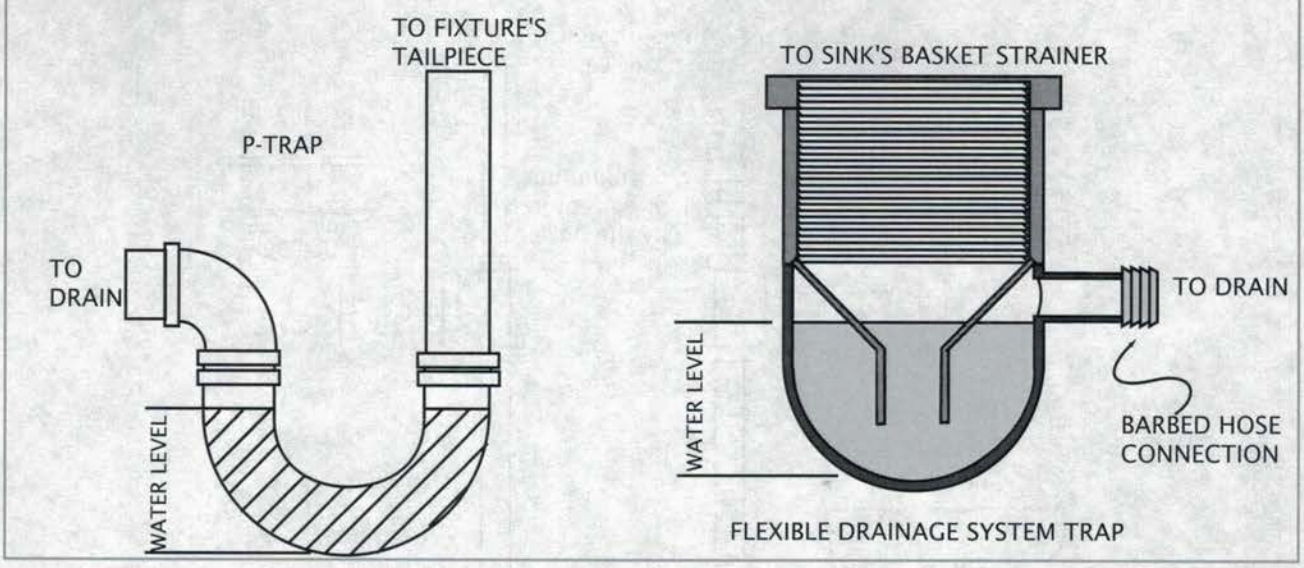
Figure 6-16 depicts a flexible drainage system that consists of a trap, flexible tubing, and termination fitting. These systems do not usually have waste holding tanks. A flexible drainage system is a listed assembly, and it uses a special trap and flexible drain hose. The flexible drainage system is only permitted on a single compartment sink or shower. They are most commonly found in folding camping trailers and small truck campers.

The drainage pipe system is primarily assembled with ABS plastic pipes and fittings. ABS is made to withstand the cold weather better than the PVC piping material.

6-1.3.3.3 Traps

Traps are installed at every fixture in the drainage system to prevent gases and odors from entering the RV through the fixture's drainage lines. These gases and odors originate from the sewage in the holding tanks or the in-ground sewer system to which the RV is connected. Traps accomplish this by creating a barrier of water that prevents gases from escaping from the downstream piping. The most common trap used is a P-trap. The shape of this trap is designed to retain a sufficient amount of water to create a barrier (water level) to prevent the escape of gases, as shown in *Figure 6-17.*

Figure 6-17 P-Trap and Flexible Drainage System Trap



6-1.3.3.4 Venting

Figure 6-18 Anti-siphon Trap Vent Device (ASTVD)

Venting is required in the drainage system at every fixture and for each holding tank. The importance of proper venting cannot be overstated, especially as it relates to odor control. In addition, without correct venting, sinks will not drain properly, bacteria can spread, and holding tanks will not drain as quickly or completely due to insufficient airflow into and out of the system. As a holding tank empties or a sink drains, fresh air must enter the drainage system. Since RV fixtures and holding tanks rely primarily on gravity to empty, having air enter the system as sinks and tanks are drained results in a faster and more thorough process.

To ensure that the water is not also drawn out of the P-traps by siphoning, venting is required to be immediately downstream of any trap. In addition to the P-traps, methane gases need to be allowed access to escape from the piping system. These vents usually release through the roof of the RV but in some cases can release through the sidewall of the RV. Vents through the roof may or may not be capped.

A device called an anti-siphon trap vent device (ASTVD), depicted in *Figure 6-18* and often referred to as a *check vent,* can sometimes be used just downstream of a trap to provide venting. This device is only a secondary vent and must be used in conjunction with the primary vent that will extend through the roof. A vent terminating through the roof allows air into and out of the drainage system. The ASTVD will allow air into the system but does not release any air or gases from the system. The ASTVD is located inside the RV, and this device does not allow system air to be released into the interior. *Figures 6-19* through *6-22* show various methods of venting drainage systems.

Figure 6-19 Methods of Venting (ASTVD, Roof Vent, and Connection with Vented Waste Line)

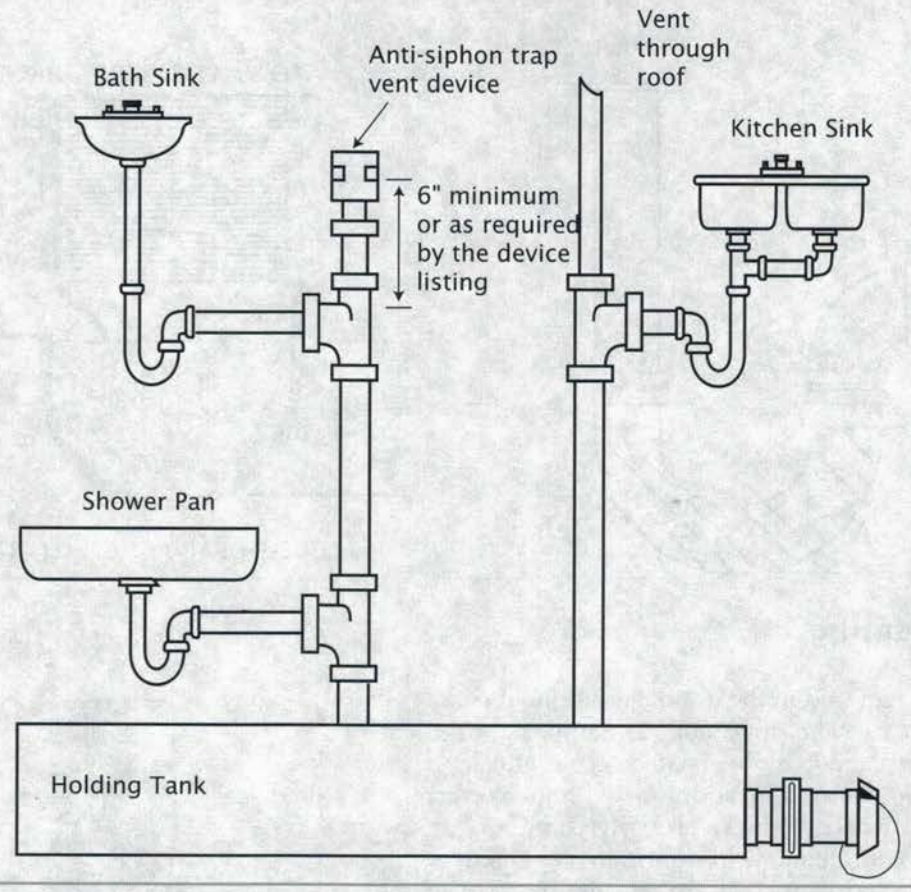


Figure 6-20 Methods of Venting (ASTVD, Roof Vent, and Connection with Vented Waste Line)

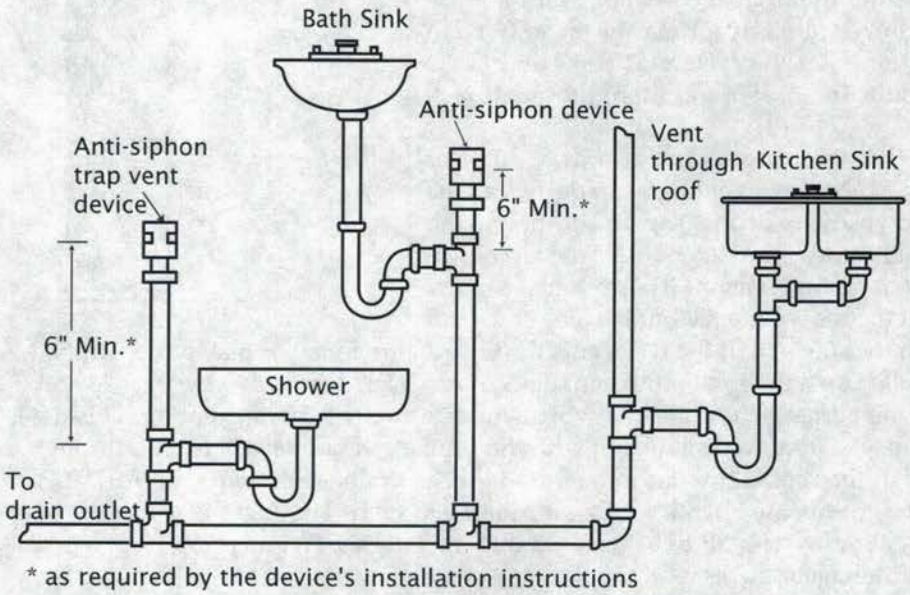


Figure 6-21 Methods of Venting (ASTVD, Roof Vent, and Connection with Vented Waste Line)

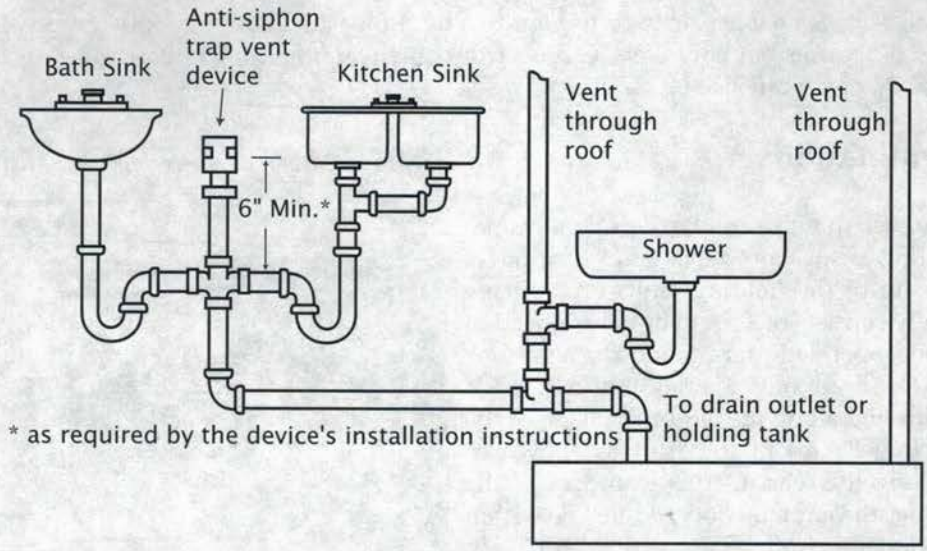
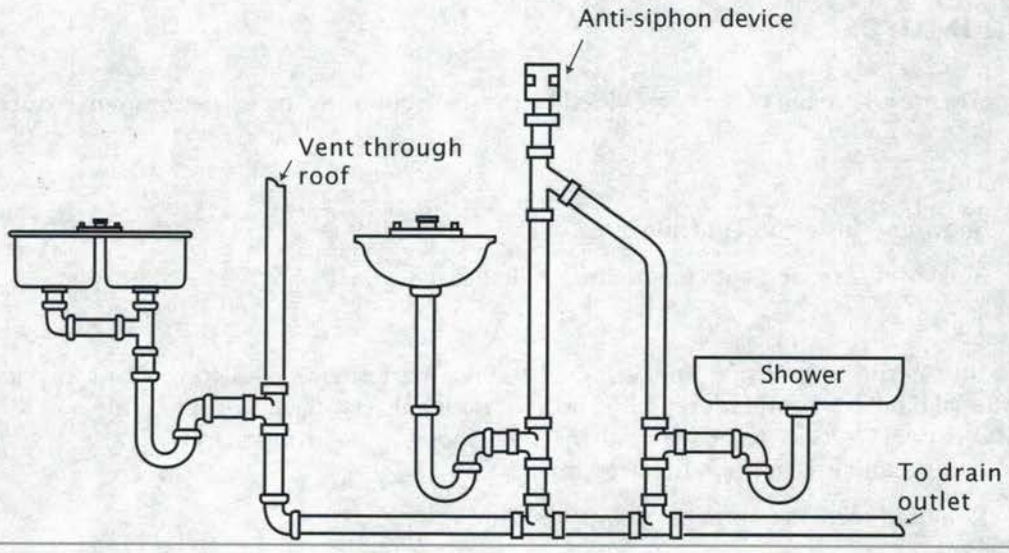


Figure 6-22 Methods of Venting (ASTVD, Roof Vent, and Connection with Vented Waste Line)



6-1.3.3.5 Holding Tanks

There is no requirement in *NFPA 1192* or *CSA Z240* that mandates the installation of either a black or gray water holding tank(s) on an RV. However, most RVs have wastewater holding tanks. Holding tanks can be made from ABS plastic or polyethylene plastic. In rare situations, waste holding tanks have been made from metal. A single holding tank can be used to collect body waste and liquid waste from sinks or tubs, or individual tanks can be used to separately collect body and liquid waste.

Black Water Holding Tank (Solid Waste)

The term *black water holding tank* (BWHT) is used to refer to a body waste holding tank that receives the discharge from any toilet. A BWHT may receive discharge from any number of additional fixtures on the RV. Holding tank outlets from BWHT must be minimum of 3 in. dia. Holding tanks are generally constructed of polyethylene (in colors of gray or light brown) and ABS (in black).

Gray Water Holding Tank (Liquid Waste)

The term *gray water holding tank* is used to refer to a liquid waste holding tank that receives the discharge from any number of fixtures but not toilets. Outlets from gray water holding tanks can be as small as 1-1/2 in. dia. pipe, but 3 in. dia. pipe can also be used.

6-1.3.3.6 Terminations

Figure 6-23 Main Drain Termination Area

The drainage system will empty at a drain termination outlet or fitting located on the exterior of the RV. This is downstream of the holding tanks or drainage system and usually consists of a drain outlet connection fitting and hand-operated termination valves or full-way valves. The drain outlet is required by the RV standards to be located along the left or roadside of the RV within 22.5 ft (6.85 m) of the rear, as shown in *Figure 6-23*, or along the rear in truck campers. If the drain outlet empties through the floor, it must be within 18 in. of the outside wall. RVs with flexible or side-vented drainage systems may have the termination on either side or at the rear.

6-1.3.4 Fixtures

The fixtures are where the water is provided by the distribution system. The common fixtures provided on RVs are:

- Tubs
- Showers—inside and outside
- Sinks—kitchen and bath (sometimes called *lavatory* or *lavy*)
- Toilets

Each fixture needs to be listed and installed within the terms of its listing. Typical plumbing listings include National Sanitary Foundation (NSF) and International Association of Plumbing and Mechanical Officials (IAPMO). The RV service technician only needs to look for the listing mark.

Fixture listing standards address the need for:

- Rounded corners to prevent debris buildup
- The strength of floor fixtures
- The slope of the fixtures to ensure that the fixture will drain in a level position
- The fixtures' color fastness and resistance to cigarette burns

6-1.3.5 Water Heaters

Water heaters are installed in the water distribution system to provide a means of supplying hot water. Most RV water heaters are either propane, 120 VAC, or both. Propane water heaters used on RVs must be specifically listed for RV use. This means the water heater has been specifically evaluated for use in an RV (vibration testing and so forth). Look for the words "listed for RV use" or similar language on the listing label of the water heater. Additional information may be obtained in the *RV Water Heaters* textbook, published by RVIA.

A water heater installation may also include a bypass kit. A bypass kit is employed during winterization procedures to "bypass" the water heater when using RV antifreeze. It eliminates the need to completely fill the

water heater so as to protect the hot water lines in the RV. Depending on the supplier, a bypass kit may incorporate one, two, or even three manual shutoff valves. In certain circumstances, constant exposure to hot water flowing through the bypass valves may cause them to fail over time. For example, if water pressure is greatly reduced at any faucet in the RV, it may be caused by faulty bypass valves. If a customer complains of lukewarm water at one or more hot faucets, a bypass valve may be partially open or completely failed. All-metal bypass valves are less likely to fail.

A check valve at the water heater's cold water inlet may be installed to prevent hot water from entering the cold water line. This may happen due to heat transfer through the water heater to the cold water line. In the event hot water seeps up the cold water line, this is not a safety issue. The use of a check valve in this position is a convenience for the owner so that when cold water is needed at a faucet, the cold water doesn't need to be run for a minute or so to get cold water from the faucet.

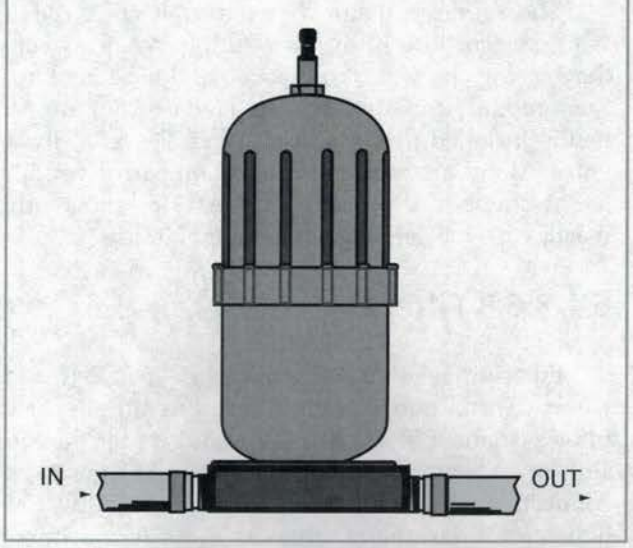
6-1.3.6 Accessories

6-1.3.6.1 Accumulators

Accumulators are basically small ABS or metal storage tanks installed in the plumbing water distribution system downstream of the pump to assist in with consistent water pressure. A typical accumulator is depicted in *Figure 6-24*. These "tanks" or accumulators decrease water sputtering and the rapid on-off pump operation found in some water systems. An accumulator acts like a pressure reserve vessel, in the sense that water can enter the bottom of the accumulator and will compress the air that is in the accumulator. When the pump comes on, the pressure of the pump will compress the air inside the accumulator and "store" pressure. When a faucet is opened in the water system, this "stored" pressure will push the water to the faucet until it is depleted and the pump senses a drop in pressure and turns on by way of its pressure switch.

The storage of air pressure comes from the fact that air, being a gas, can be compressed, but liquids cannot. Periodically, air must enter back into the accumulator because the air slowly releases out of the accumulator during water flow. There are two ways the air can be replaced. The first method is by draining the whole water system and opening the fitting at the top of the accumulator to let air in. The second can be accomplished by allowing the air to enter through an air hose connected to the fitting on the top of the accumulator—but only if it is equipped with an air fitting. Perform this procedure by simply turning off the water pump and opening a faucet. Let the air enter into the accumulator air fitting until air is released from the faucet. There is no need to pressurize the system with high pressure; just slowly feed air into the accumulator fitting.

Figure 6-24 Accumulator



In addition to the type of accumulator previously described, there is a type of accumulator that uses a diaphragm between the water and the air side of the tank. In order to charge the air side of the unit, first drain the water side by opening a water faucet with no water pressure being supplied to the coach. Next charge the air side using a compressor or air pump with approximately one-half the normal water system pressure required, or approximately 20 psi air pressure. Close the water faucet and turn on the pump or city water pressure. The accumulator will do all the things the previously discussed accumulator does without losing air pressure in the system. No check valves are required between the accumulator and water distribution system, even though some RV manufacturers install a check valve in the cold water line at the water heater. This check valve would have to be removed for proper operation of the accumulator. Removing the referenced check valve will not affect the operation of the water heater. A defective check valve may reduce or stop the water flow on the hot water side.

Accumulators can also be used to eliminate the potential cause of black run marks or streaking typically referred to as "dripping/weeping" on the RV's exterior below the water heater. This is caused by a faulty temperature and pressure relief valve (T&P valve) in the water heater.

This weeping takes place because the RV water system is "closed." Once water enters into the RV's water system, the only way it can be released is through the fixture valve. The check valves at the city water service connection and at the water tank/pump area make the RV water system "closed." When the water heater heats the water, it expands, creating a problem if the water heater tank is full, because the system has more pressure on it and the water can't be released. This will result in the "weeping" of the water heater's T&P valve.

Adding an accumulator tank to the system will help to eliminate this condition, because it allows the expanding heated water a place to go without activating the T&P valve. The accumulator tank will help prevent the water heater from weeping, but it will not eliminate it. If the air pocket in the water heater is emptied, the accumulator will absorb some of the expanding water pressure before the T&P valve drips. However, the air in the accumulator is much smaller than the air pocket in the water heater tank and will also pressurize much faster, which causes the air in the accumulator to empty more quickly than the water heater. It is important to maintain the air pockets in both the water heater tank and accumulator. The accumulator simply serves as an aid in absorbing the water expansion. Accumulator tanks are usually available on high-end coaches but could be an option on mid- to low-price units.

6-1.3.6.2 Regulators

The city water regulator guards and protects the pump and other water system components against the damage created by the pressures of unregulated city water hookups. If a hose-type water regulator is used, a good place to install it is at the campground faucet to avoid the high water pressure from the campground to the RV's water supply hose. If an RV has a water pressure regulator built into the coach, an in-line regulator can still be used at the campground faucet. Water regulators help by reducing pressures, which can be as high as 150 psi, to approximately 40 to 50 psi. They contain backflow preventers and strainers to keep debris and grit out of the water system.

The in-line regulator shown in *Figure 6-25* is a model with garden hose fitting that simply connects between the existing city water connection and hose hookup. The flush-mount unit depicted in *Figure 6-26* is a permanently installed model that also doubles as a city water entry. Many are made of brass, non-corrosive, durable acetyl copolymer (Celcon) and ABS plastics with soft plastic caps to keep dirt out when not in use.

Figure 6-25 In-Line Regulator

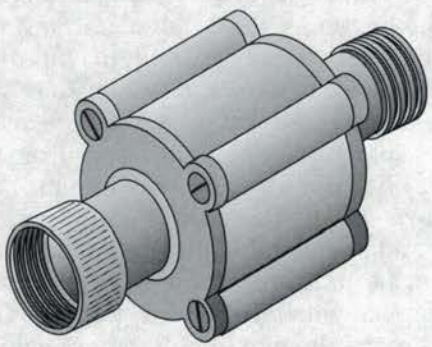
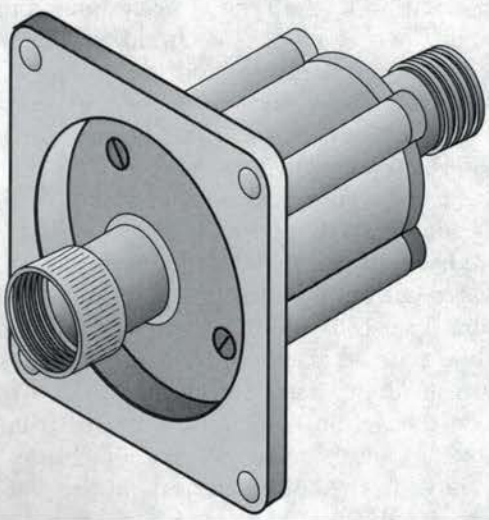


Figure 6-26 Flush Mount Regulator



6-1.3.6.3 Filters

Filtering systems are sometimes installed into the water distribution system. These are simple cartridge filter systems that are usually found under the kitchen sink or in a storage compartment near the city water connection. Water filters installed in an RV water system serve the same function as those found in conventional homes. They filter out slight impurities in the water that can affect the texture and taste. This is especially true for RV owners who travel all over the country and use water from multiple systems and supply sources. The filters need to be replaced periodically in con-

formance with the owner's manual provided with each unit. Usually, the filtration units (as depicted in *Figure 6-27*) are small and are inserted into the piping system just before the main water faucet in the kitchen or galley area. These small filters are typically installed to the cold water inlet side of a single faucet. Larger filters are needed for an entire piping system.

6-1.3.6.4 High-Pressure Check Valves

When located at the pump outlet, these pressure check valves protect the pump from the damaging pressure of unregulated city water connections. They can also be located at the water heater inlet to prevent backflow of hot water into the cold water system and pump.

6-1.3.6.5 In-Line Strainer

RV water systems usually have an in-line water strainer. These strainers usually contain a simple screen material designed to capture dirt, sand, and other debris before it gets into the water system. These strainers are similar to filters but do not remove the impurities from the water. *Figure 6-28* shows a strainer installed between the potable water tank and the water pump. Refer to the installation manual for the best method and locations for installing the strainer. Some strainers come with a transparent housing for quick and easy inspection. Most in-line strainers are built so that they can be easily disassembled, cleared of any debris, and reassembled without any sealants or glues.

In addition to the basic in-line strainer, some pumps have the strainers preinstalled into their inlet fittings. They can also be incorporated into the fitting that is screwed into the water tank. This type of strainer will usually not need any kind of servicing, unlike the type that is installed in line as shown in *Figure 6-28*.

Figure 6-27 Cartridge-Type Water Filter

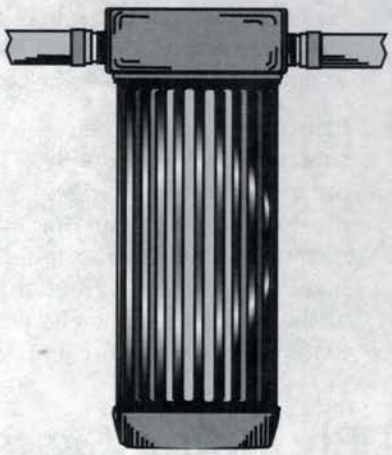
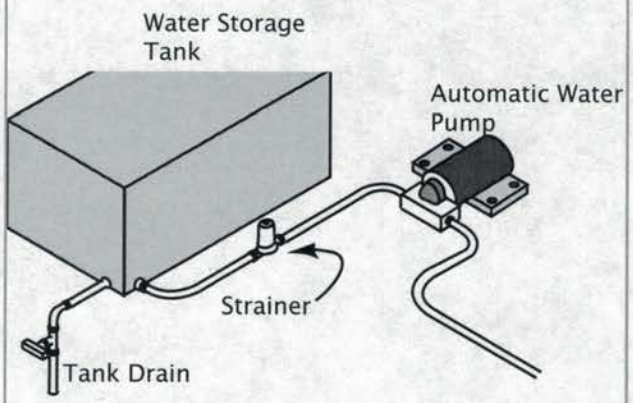


Figure 6-28 Strainer Installed Between Water Tank and Pump



6-1.3.7 Using Pressure Gauges

Pressure gauges are used when testing water distributions systems for leaks, as shown in *Figure 6-29*. Important tips for inspecting the pressure gauges before testing are:

- Gauges should be capable of measuring the test pressure needed and should be calibrated in increments no larger than 2 psi.
- Inspect the gauges before testing to make sure they work properly. Gauges with a broken or missing cover glass, bent needles, or needles that don't return within one increment of zero should be discarded. It recommended that an annual calibration of the pressure gauges be performed so as to make sure it functions properly.

Figure 6-29 Pressure Gauge

6-1.4 Plumbing System Special Tools

Special tools are used for the assembly of some water distribution system materials (PB and PEX). These are discussed in *Chapter 6-2*.

6-1 Review

1. List the two purposes of an RV plumbing system.
   A.
   B.
2. Explain how the RV plumbing system is different from that found in a house.
3. Which of the following statement(s) is/are not true?
   A. The type of plastic pipe normally used in RV drainage systems is called PVC (polyvinyl chloride).
   B. The color of the piping used in RV drainage systems is usually black.
   C. The type of material is printed along the length of the pipe.
   D. The type of material is not marked on fittings.
4. DWV stands for:
   A. Distribution water valve
   B. Disposable water valve
   C. Drain, waste, vent
   D. Detachable waste valve
5. DWV piping is sized by:
   A. The length of the piping system
   B. The type of RV it is to be used in
   C. The wall thickness of the pipe
   D. The inside diameter of the pipe
6. The typical schedule size for ABS DWV piping used in RVs is:
   A. Schedule 10 or equivalent
   B. Schedule 20 or equivalent
   C. Schedule 30 or equivalent
   D. Schedule 40 or equivalent
7. List the five major components of a water distribution system.
   A.
   B.
   C.
   D.
   E.
8. Explain what "listed" means.
9. List the two things required for an RV water distribution system.
   A.
   B.

10. List the four types of water systems used in RVs.
    A.
    B.
    C.
    D.
11. Which of the following is the function of a check valve?
    A. Prevents the water pump from being damaged by over pressure
    B. Prevents the back passage of air
    C. Prevents water from back-flowing into the pump or storage tank
    D. Allows for the flow of air to or from a drainage system
12. Which of the following is not a type of plastic piping used for RV water distribution systems?
    A. PVC
    B. CPVC
    C. PB
    D. PEX
    E. PTRV
13. Copper may never be used for RV water distribution systems.
    True False
14. How many types of plumbing system tanks are usually found on an RV? Name them.
15. PVC piping may never be used for RV drainage system piping.
    True False
16. Identify the document that establishes the plumbing requirements for RVs.
17. According to that document, every fixture in the drainage system and every holding tank is required to be vented.
    True False
18. An anti-siphon trap vent device (ASTVD) may be substituted for a primary vent.
    True False

19. Match the following:

_____	Accumulator	A. A device that protects the water pump and other components from excessive water pressure
_____	Pressure gauge	B. A device designed to remove impurities from the water
_____	Filter	C. A device that, when located at the pump outlet, protects the pump from excessive water pressure and, when located at the water heater inlet, prevents backflow of hot water into the cold water system
_____	High-pressure check valve	D. A device that decreases water pulsation and the rapid on-off pump operation
_____	Regulator	E. A device used when performing a leak test of the water distribution system

20. Explain the purpose of a P-trap.

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Chapter

6-2 RV Plumbing System Installation and Repair

6-2.1 Distribution Systems

To maintain the RV's plumbing systems, the RV service technician must be able not only to identify the types and kinds of materials used by the RV manufacturer in the original installation of the plumbing systems, but also to develop the necessary skills needed to change or otherwise modify the distribution system. This may include cutting, connecting, routing, and bending of piping materials.

With regard to plumbing systems, the terms *pipe* and *tube* are frequently used interchangeably in various technical publications. This textbook, like *NFPA 1192* and *CSA Z240*, uses the term *piping* as a general classification of both pipe and tube. The specific term *pipe* or *tube* is used when the discussion is to be applied only to that item.

Although typically installed by the coach manufacturer in compliance with *NFPA 1192*, the way in which the distribution piping was installed may cause operational problems. For example, when excessive vibration noise, or "hammering," is experienced while the water pump is running, it is possible that the distribution piping is not properly secured or too far apart between intervals. This is more common in slide rooms containing plumbing fixtures. In some cases, the method used to secure the piping allowed it to come loose during RV travel. It is important that all types of freshwater distribution piping must be secured and routed properly.

6-2.1.1 Piping

6-2.1.1.1 Plastic

There are three common types of pressure approved plastic piping used in RV water distribution systems. They are:

- Polyethylene cross-linked (PEX)
- Polybutylene (PB)
- Chlorinated polyvinyl chloride (CPVC)

All three plastic piping types are listed for use with both hot and cold water installations. PB distribution systems will be more frequently used than the other two types of piping listed above. The Shell Chemical Company (holder of the patent) is not currently manufacturing PB for use in the United States. This is because of a class action lawsuit filed by homeowners because of problems with these systems. There have not been PB problems in RVs. However, the overall impact has been so great that Shell has discontinued the product in the U.S.A. Later-model RVs will have a different type of piping system

PEX Tubing and Installation Procedure

The PEX tubing is manufactured using three different methods:

- Engel method (type A)
- Silane method (type B)
- Radiation method (type C)

The type of PEX material in an RV system can be identified by the markings on the walls of the tubing. Each PEX tubing will be marked type A, B, or C.

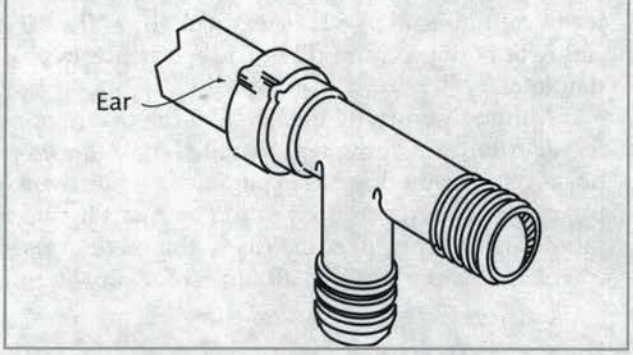
Type "A" PEX is considered "hot" cross-linked, because a hot or cold semisoft solid plastic is extruded or forced through the opening of a die, while in a molten state, to produce a continuously formed piece in the shape of the desired tubing.

Types "B" and "C" are "cold" cross-linked materials, because the cross-linking process occurs after the extruding process as a secondary step. This does not mean one type can only be used for hot water applications or only cold water applications. It simply refers to the manufacturing method of the tubing. Type A tubing can be heated to fix kinks or to thaw frozen water lines. Types "B" and "C" should not be heated, because the heat can reduce the pressure characteristics of the tubing, which can cause the tube to burst or crack.

When repairing or replacing the components of a PEX distribution system (piping, fittings, and so forth) make sure the PEX material used is a type that is compatible with another. Keep in mind that fittings, sizes, pressure ratings, and composition may all vary.

PEX tubing systems commonly use fittings and crimp rings or clamps similar to those used in PB systems. The fittings are either metal or plastic, and the crimp rings are copper, but colored black. The procedure outlined previously for PB tubing installation may be used for PEX tubing installations. The fittings and crimp rings are slightly different, but the same crimp tool and go/no-go gauge can be used. Technicians should be aware that older crimp tools for PB piping that leave "ears" on the crimp ring as shown in *Figure 6-30* are unacceptable for use in PEX systems.

Figure 6-30 Crimp Ring with "Ears"



PEX/PB transition fittings are available for use when the technician must use PEX tubing to repair a PB system. PEX and PB tubing are slightly different diameters. Therefore, interchanging PEX and PB without the specially designed transition fittings will most assuredly lead to leaks in the repaired system. There are transition fittings for PEX and PVC or CPVC fittings also.

PEX/Polybutylene (PB) Uponor Installation Procedure

Uponor's exclusive ProPEX® fittings make solid, permanent connections without torches, glues, or gauges. The unique shape memory of Wirsbo AQUAPEX®, WirsboAQUAPEX® plus, and Wirsbo hePEX™ plus forms a tight seal around the fitting, creating a strong, reliable connection.

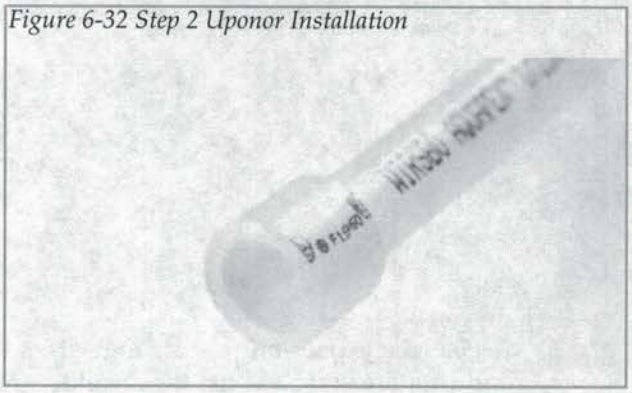
The following steps show how to make proper ProPEX connections using one of Uponor's expander tools (battery, air, or hand). The steps are virtually the same for all three tools, with a slight variation for the type of tool used.

1. Square cut the PEX tubing perpendicular to the length of the tubing. Remove all excess material and burrs that might affect the fitting connection.

Figure 6-31 Step 1 Uponor Installation

2. Slide the ProPEX Ring over the end of the tubing. Extend the end of the ring over the end of the tubing no more than 1/16 in. (1 mm).

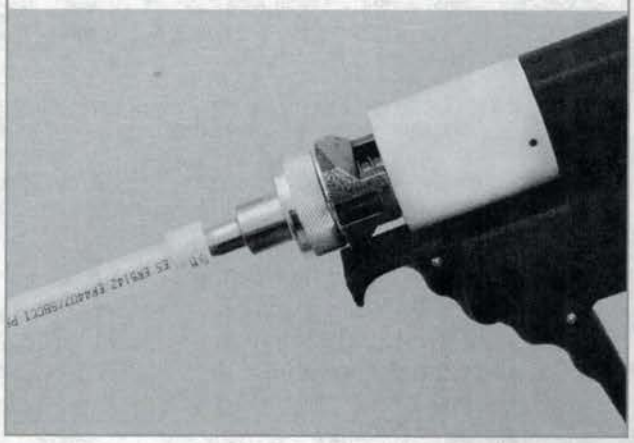
Figure 6-32 Step 2 Uponor Installation



3. When using the ProPEX hand expander tool, brace the free handle of the tool against a hip or place one hand on each handle. Fully separate the handles and slide the expander head into the tubing until it stops. Full expansions are necessary to make a proper connection. Bring the handles together to expand. Separate the handles, remove the head from the tubing, and rotate it one-eighth turn. Slide the tool head into the tubing in the newly rotated position and expand again.

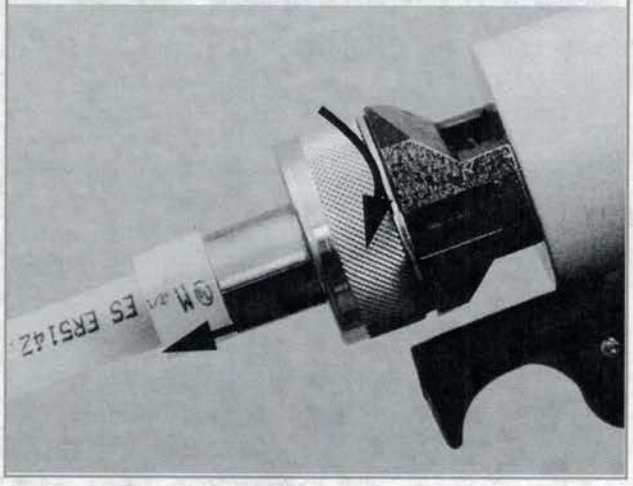
4. When using the ProPEX air or battery expander tools, slide the expander head into the tubing until it stops. Full expansions are necessary to make a proper connection. Press the trigger to expand.

Figure 6-33 Step 4 Uponor Installation



5. Release the trigger, remove the head from the tubing, and rotate it one-eighth turn after each expansion. Slide the tool head into the tubing in the newly rotated position and expand again.

Figure 6-34 Step 5 Uponor Installation



NOTE: For the hydraulic battery expander tool, a click will be heard after each expansion.

NOTE: Rotate the tool one-eighth turn in either direction after each expansion to provide smooth and even expansion of the tubing. If the head is not repositioned after each expansion, the segments on the tool head may cause deep grooves in the tubing. These grooves can result in potential leak paths.

NOTE: It is not necessary to rotate the tool in only one direction. Alternating the turning direction will ease expansion in confined spaces. *Figure 6-35* and *Figure 6-36* show enlarged views inside expanded tubing.

Figure 6-35 Expansion with Proper Rotation

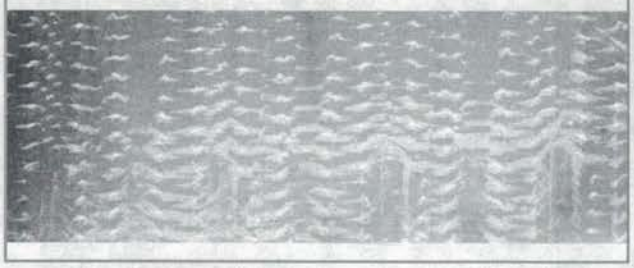
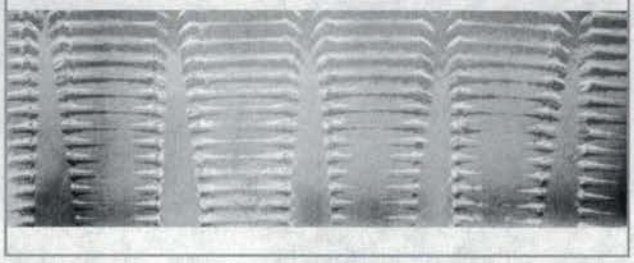


Figure 6-36 Expansion without Proper Rotation

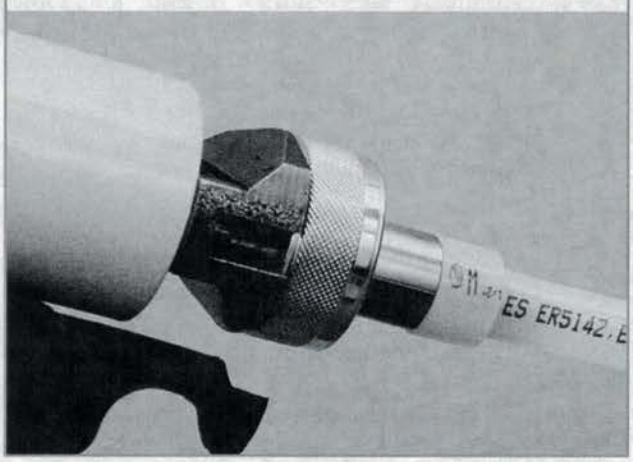


6. Repeat the expansion process until the tubing and ring are snug against the shoulder on the expander head. See *Table 6-1* for the recommended number of expansions for each tubing size.

NOTE: "H" referenced in *Table 6-1* refers to the H-series expander heads.

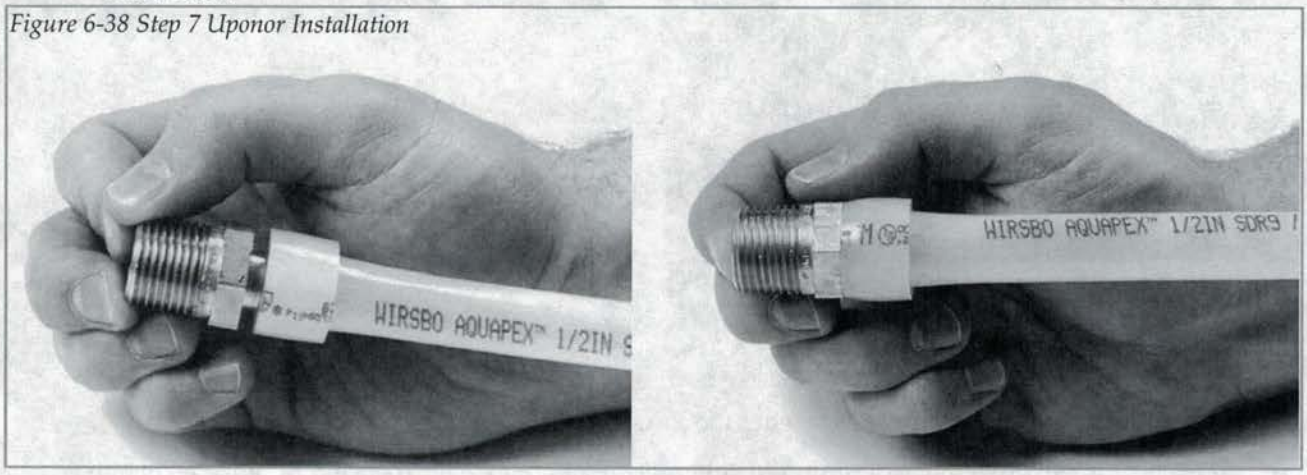
NOTE: The ProPEX 100 battery expander tool only expands up to 1 in. tubing.

Figure 6-37 Step 6 Uponor Installation



7. Immediately remove the ProPEX Expander Tool. Some resistance should be felt as the tubing is slid over the fitting. If the tubing reaches the shoulder of the fitting without any resistance, the tubing may be overexpanded and may require additional time to fully shrink over the fitting. The tubing and ProPEX Ring should seat against the shoulder of the fitting for a proper connection.

Figure 6-38 Step 7 Uponor Installation



Important Tips for a Proper ProPEX Connection

- If the fitting does not slide into the tubing all the way to the stop, immediately remove it from the tubing and expand the tubing one final time.

NOTE: To avoid overexpanding the tubing, do not hold the tubing in the expanded position.

- The number of expansions in *Table 6-1* is the recommended number of expansions. Experience, technique, and weather conditions influence the actual number of expansions. Fewer expansions

may be necessary under certain conditions. The correct number of expansions is the amount necessary for the tubing and the shoulder of the fitting to fit snugly together.

- Good connections result when the ProPEX Ring rests snugly against the stop of the ProPEX fitting shoulder. If there is more than 1/16 in. between the ring and the shoulder of the fitting, square cut the tubing 2 in. away from the fitting, and make another connection using a new ProPEX Ring.

Table 6-1 Tubing Size Expansions

Tubing Size	Ring Marking	Head Marking			Number of Expansions		
		Hand	Air	Battery	Hand	Air	Battery
3/8 in.	3/8 in.	3/8 in.	3/8 in.	---	4-5	4-5	6-7
1/2 in.	1/2 in.	1/2 in.	1/2 in.	---	3-4	3-4	3-4
3/4 in.	3/4 in.	3/4 in.	3/4 in.	3/4 in. H	7-9	7-9	6-7H
1 in.	1 in.	1 in.	1 in.	1 in. H	12-14	12-14	6-7H
1-1/4 in.	1-1/4 in.	---	---	1-1/4 in. H	---	---	6-7H
1-1/2 in.	1-1/2 in.	---	---	1-1/2 in. H	---	---	6-7H

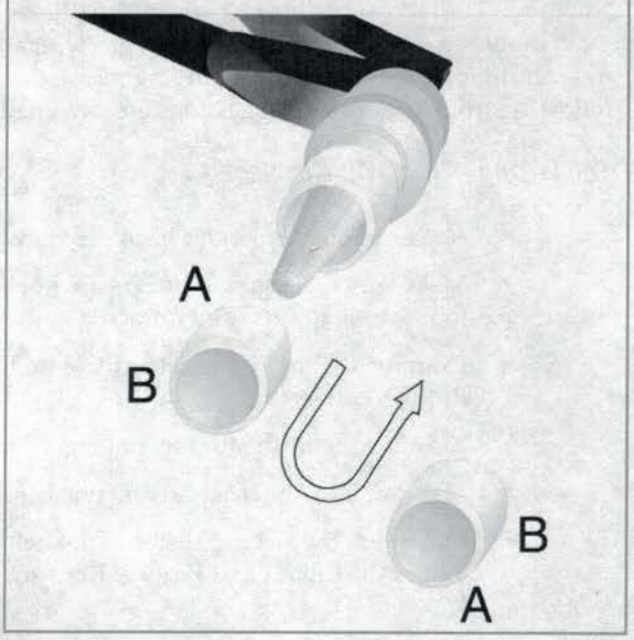
Making 3/8 Inch ProPEX Connections

The 3/8 in. ProPEX Ring is smaller and thicker than the ProPEX Rings used for other tubing sizes. The 3/8 in. ProPEX Ring must be expanded once on each side to properly fit over the tubing. Expansion of the ProPEX Ring is only necessary for 3/8 in. PEX.

1. Square cut the 3/8 in. PEX tubing perpendicular to the length of the tubing (see *Figure 6-31*).
2. Expand each side of the 3/8 in. ProPEX Ring with the ProPEX Expander Tool once.
3. Slide the expanded 3/8 in. ProPEX Ring over the end of the tubing. Extend the end of the ring over the end of the tubing no more than 1/16 in. (1 mm).

Once the 3/8 in. ProPEX Ring is properly expanded and on the tubing, refer to steps 3 through 5, beginning on *page 6-25*, for further instruction.

Figure 6-39 Uponor Expander Tool



Important Tips for a Proper 3/8 Inch ProPEX Connection

- When the temperature is above 40°F, ProPEX connections to 3/8 in. PEX tubing require four to five expansions. When the temperature is below 40°F, only four expansions are necessary.

- The thicker ProPEX Ring used for 3/8 in. ProPEX connections shrinks over the fitting faster than other size rings.

Disconnecting a ProPEX Brass Fitting

ProPEX Brass Fittings are manufactured connections and can be concealed in walls, ceilings, and floors. However, when necessary, ProPEX Brass Fittings can be disconnected. (APR and EP fittings cannot be reclaimed or reused.) To disconnect a ProPEX Brass Fitting:

1. Make sure the system is not pressurized.
2. Use a heat gun to heat one side of the ProPEX Ring. When the ring is clear, use a utility knife to carefully cut through the ring. Take care to cut only the ring and not the tubing. This will protect the fitting from being gouged by the knife. Remove the ProPEX Ring from the tubing with pliers or another tool to avoid touching the hot ring.

NOTE: Do not gouge the fitting when cutting the ProPEX Ring. Nicks and gouges in the fitting may result in leaks. If nicked, discard the fitting.

3. Remove the ProPEX Ring and apply heat directly around the fitting and tubing connection. Gently work the tubing back and forth while pulling slightly away from the fitting until the tubing separates from the fitting.
4. After removing the tubing from the fitting, square cut the tubing 2 in. (minimum) from the end of the tubing.
5. Use a new ProPEX Ring and follow the steps to make a new ProPEX connection. Allow the fitting to cool before attempting to make another connection.

Troubleshooting ProPEX Connections

Trouble-free ProPEX installations begin with a ProPEX Expander Tool that is maintained in proper working condition. If the tool or segment fingers are damaged, it is very difficult to make a proper connection. The following troubleshooting suggestions are designed to assist with problems in the field.

For Fittings That Will Not Seal:

- Make sure the expander head is securely screwed onto the tool (hand tightened).
- Make sure the segment fingers are not bent. If the head does not completely close when the battery tool's drive unit is fully retracted or the handles of the manual tool are open, replace the head.
- Examine the tool for excess grease on the segment fingers. Remove excess grease prior to making ProPEX connections.
- Examine the fitting for any damage. Nicks and gouges on the fitting will cause the fitting to leak.
- Make sure the internal driver cone is not damaged or bent.
- Make sure the last expansion is not held in the expanded position before the fitting is inserted. The longer the tubing and ProPEX Ring are held in the expanded position, the greater the chance for a leak.
- Be sure to rotate the tool one-eighth turn after each expansion.

If Expansion is Difficult:

- Make sure the internal cone is properly greased.

If the Expansion Head Slips Out of the Tubing When Making Expansions:

- Ensure that the tubing and ProPEX Ring are dry.
- Make sure that grease is not getting into the tubing.
- Examine the segment fingers to make sure that none is bent.

If the ProPEX Ring Slides Down the Tubing During Expansion:

- Ensure that the hands are clean while handling the tubing. Any sweat or oils on hands can act as a lubricant. Due to the smoothness of PEX, any form of lubricant can cause the ProPEX Ring to slide across the tubing during expansion.
- If it is anticipated that the ProPEX Ring may slide down, position the ring slightly farther over the end of the tubing and make the first couple of expansions slowly. Once the ring and the tubing begin to expand together, continue with the normal number and type of expansions.
- Placing a thumb against the ProPEX Ring will provide support and feel for any movement. If caught early, slide the ring up the tubing and expand as described in the previous bullet point.

If More Than the Recommended Number of Expansions Are Needed to Make a Connection:

- Make sure that the head is hand tightened to the expander tool.
- Examine the segment fingers to make sure that none is bent.
- Be sure to completely cycle the tool on each expansion (i.e., close the manual tool handle or release the battery expander tool trigger).

Cold-Weather Expansions:

- Temperatures affect the time required for the tubing and ring to shrink onto the fitting. The colder the temperature, the slower the contraction time.
- Warming ProPEX fittings and ProPEX Rings reduces contraction time. Put fittings and rings in pockets prior to installation to keep them warm.
- Make ProPEX connections at temperatures above 5°F (–15°C).
- Fewer expansions are necessary in temperatures below 40°F.

Uponor SSC Fitting System

The stainless steel clamp (SSC) fitting system utilizes a patented stainless-steel "stepless" clamp to secure Wirsbo AQUAPEX® and Wirsbo AQUAPEX plus tubing to SSC insert fittings.

The clamps provide a 360° uniform seal, which is constantly maintained by the unique spring action of the clamp's ear. The elastic memory of Wirsbo AQUAPEX tubing also engages the clamp's spring action, resulting in an ever-tightening, leak-free connection.

The SSC connection withstands extreme water pressure, temperature changes, and multiple freeze cycles. Use the SSC ratchet tool (P6273810) to assemble all sizes of SSC clamps.

Connection Instructions

To make a proper SSC connection, refer to the following instructions.

1. Make a clean, straight cut perpendicular to the length of the tubing as shown in *Figure 6-41*.
2. Slide the clamp over the tubing end as shown in *Figure 6-42*.

Figure 6-40 Tighten POL with Wrench (Pre-2002)

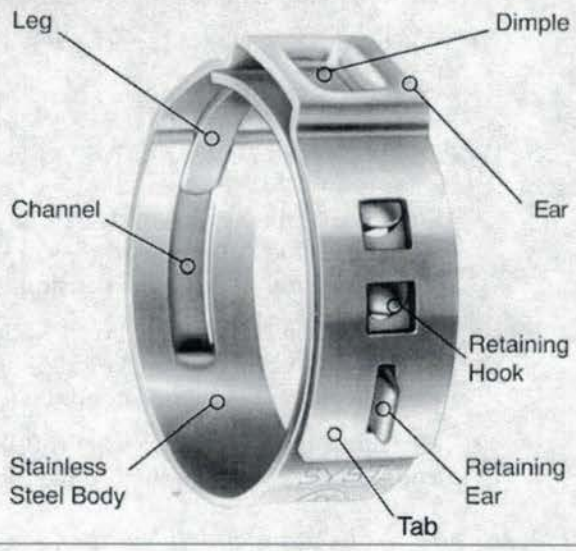


Figure 6-41 Uponor SSC Fitting Installation Step 1

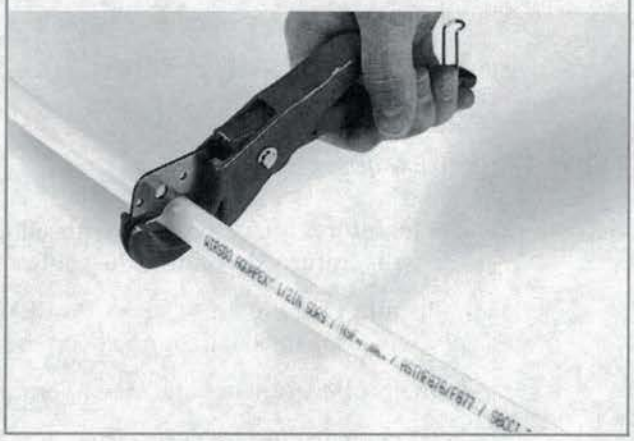
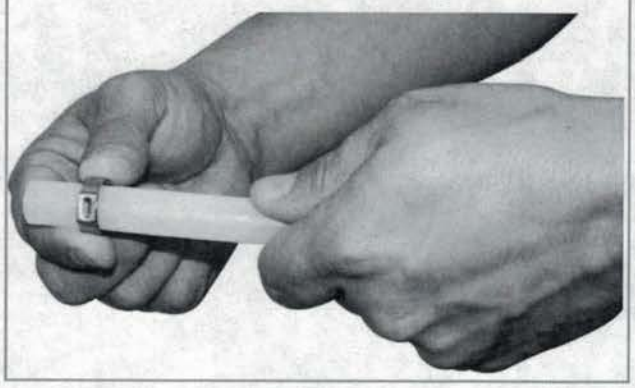
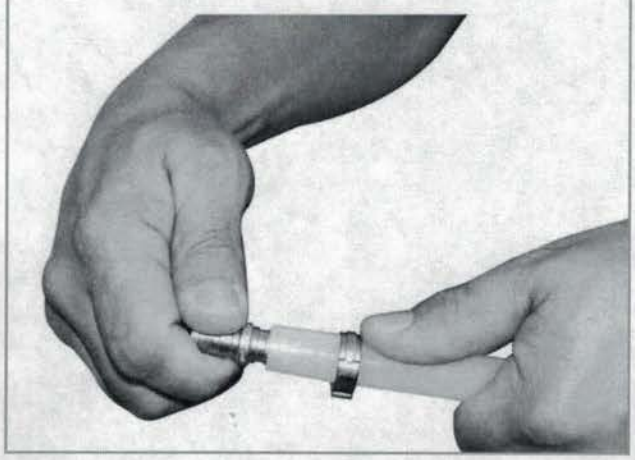


Figure 6-42 Uponor SSC Fitting Installation Step 2



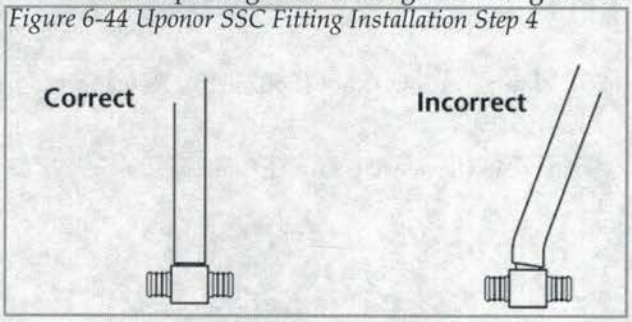
3. Insert the SSC fitting into the tubing end, making sure the tubing is fully seated over the insert barb as shown in *Figure 6-43*.

Figure 6-43 Uponor SSC Fitting Installation Step 3



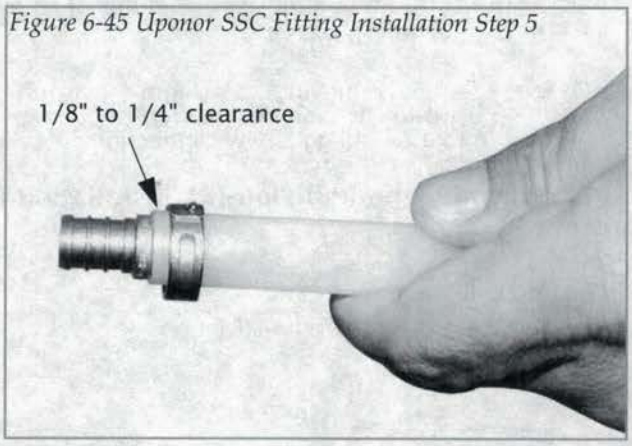
4. Ensure that the tubing is straight as it approaches the fitting and has sufficient slack or support to avoid pulling or stretching the tubing to reach the fitting.

Figure 6-44 Uponor SSC Fitting Installation Step 4



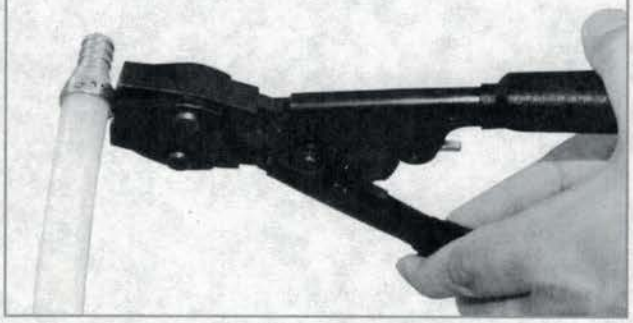
5. Position the clamp so it is 1.8 to 1.4 in. from the tubing's cut end as shown in *Figure 6-45*.

Figure 6-45 Uponor SSC Fitting Installation Step 5



6. Place the opened jaws of the SSC ratchet tool over the raised ear of the clamp as shown in *Figure 6-46*. Ensure that the clamp is still properly positioned.

Figure 6-46 Uponor SSC Fitting Installation Step 6



7. With the tool held perpendicular to the tubing as shown in *Figure 6-47*, begin to compress the tool handles.
8. Continue until a click is felt. The tool is now engaged, and the clamp is locked onto the tubing.
9. Fully compress the tool handles together to complete the assembly. After releasing the tool, the fitting should have a butterfly crimp as shown in *Figure 6-48*.

Figure 6-47 Uponor SSC Fitting Installation Step 7

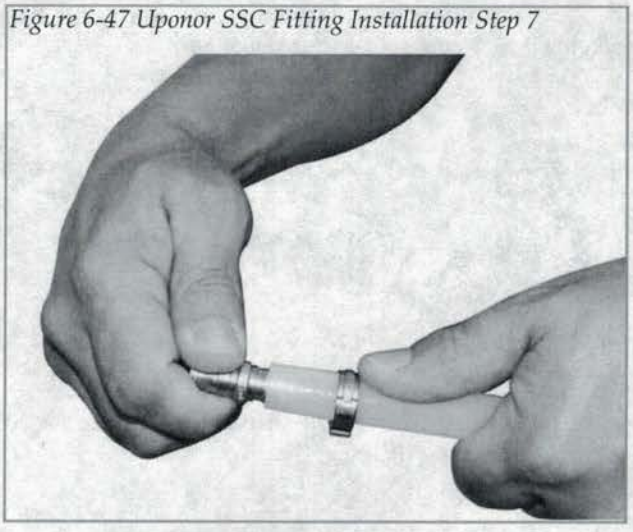


Figure 6-48 Uponor SSC Fitting Installation Step 8

NOTE: The ratchet tool will not release until the assembly is complete.

Removing a Completed Connection

If necessary, remove SSC clamps with the use of an SSC clamp removal tool (P6073810). Refer to the following instructions to properly remove an SSC clamp.

1. Using the SSC clamp removal tool, grab the edge of the clamp tab and retaining ear with the tool's jaws as shown in *Figure 6-49*.
2. Rotate the tool, pulling the tab up and away from the retaining ear. The clamp disengages from the retaining ear, making it easy to remove the clamp.

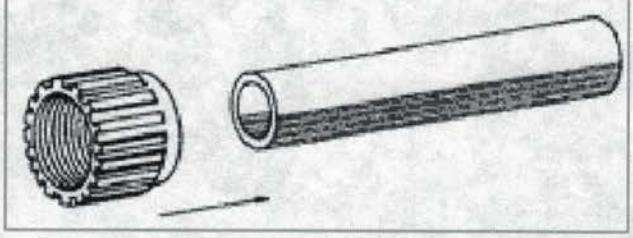
Figure 6-49 Uponor SSC Fitting Removal

NOTE: After removing a clamp, cut off the previously clamped section of tubing prior to assembling a new connection.

PEX/Polybutylene (PB) Flair-It™ Installation Procedure

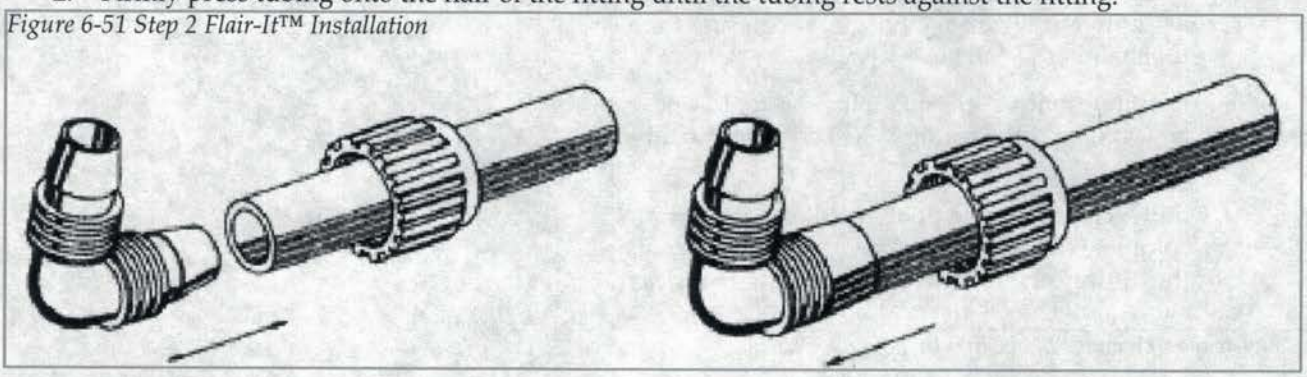
1. Slide nut over tubing.

Figure 6-50 Step 1 Flair-It™ Installation



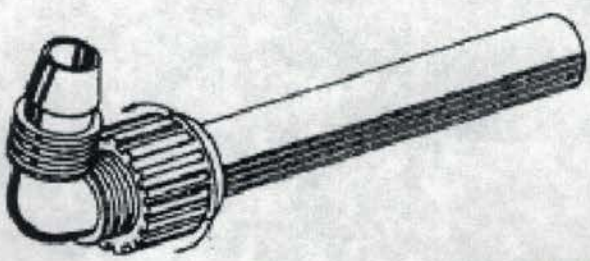
2. Firmly press tubing onto the flair of the fitting until the tubing rests against the fitting.

Figure 6-51 Step 2 Flair-It™ Installation



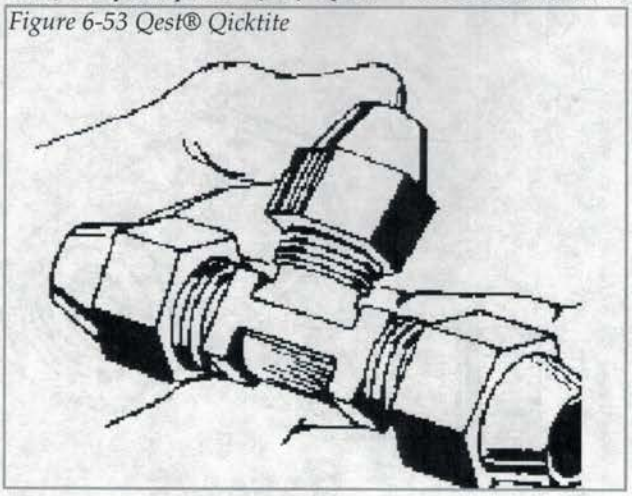
3. Slide the nut to the threads and tighten securely onto the fitting.

Figure 6-52 Step 3 Flair-It™ Installation



PEX/Polybutylene (PB) Qest® Installation Procedure

Figure 6-53 Qest® Qicktite



1. The Qicktite® nut-ring-cone connection is ideal for remodeling or repair.
2. It allows for connection of Qest® to copper, CPVC, or polybutylene.

Figure 6-54 Step1 Qest® Installation

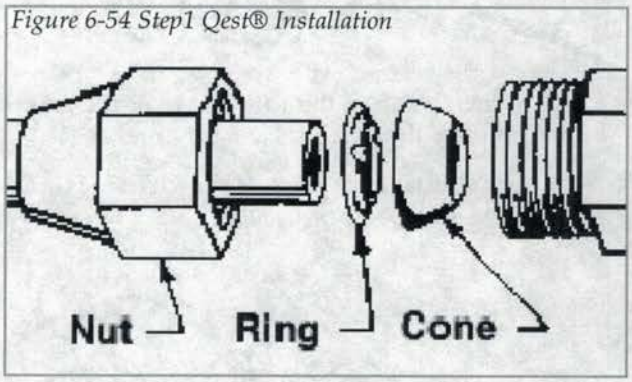
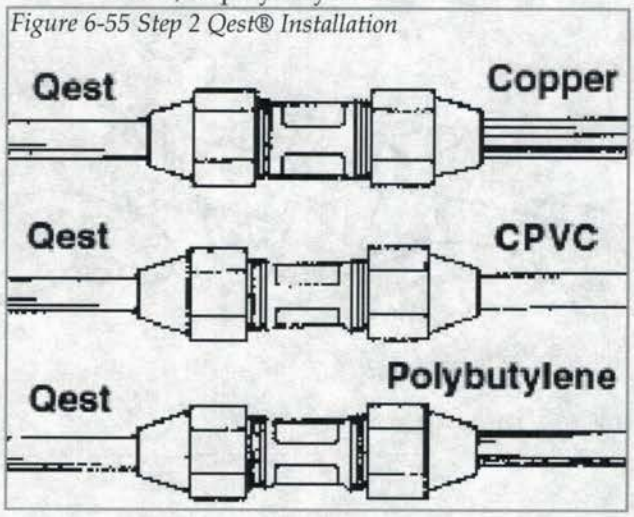


Figure 6-55 Step 2 Qest® Installation



3. Use a Qest® adapter fitting for connecting to galvanized pipe.
4. To make a connection, slip the nut onto the pipe.

Figure 6-56 Step 3 Qest® Installation

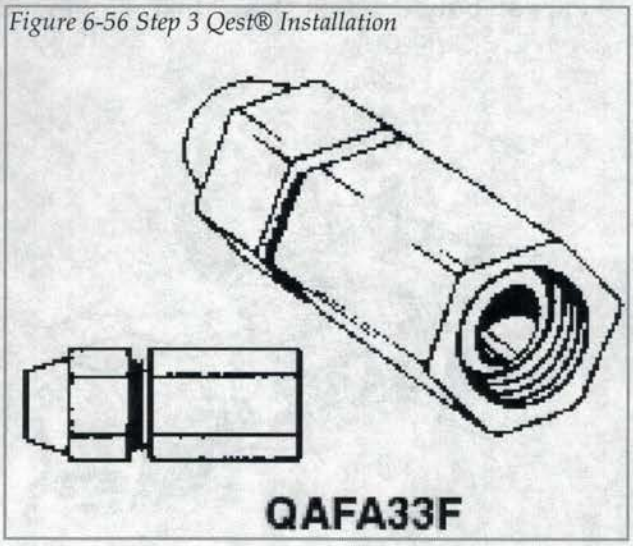
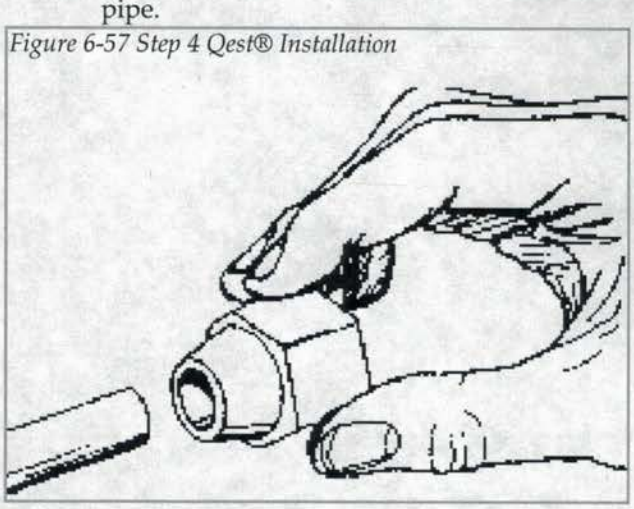


Figure 6-57 Step 4 Qest® Installation



5. Next, position the ring just over the end of the pipe with the teeth facing the end.
6. Put the cone in place as shown in *Figure 6-59*.

Figure 6-58 Step 5 Qest® Installation

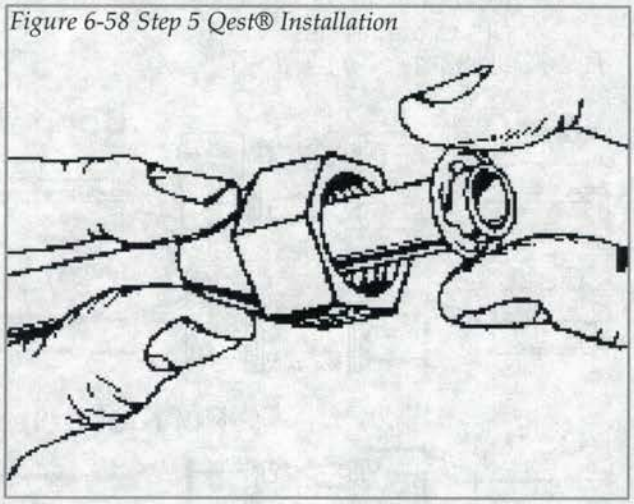
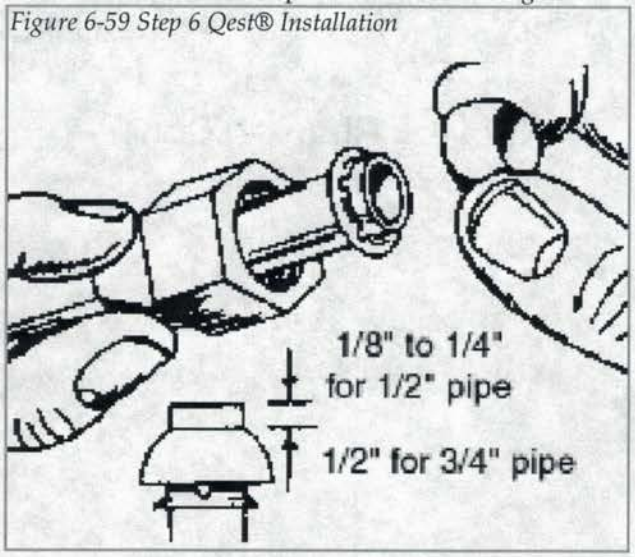


Figure 6-59 Step 6 Qest® Installation



7. The slide the nut over the cone.

8. Tighten the nut onto the fitting until it squeaks. Then give it one full turn with the wrench. Test for leaks and tighten more if necessary.

Figure 6-60 Step 7 Qest® Installation

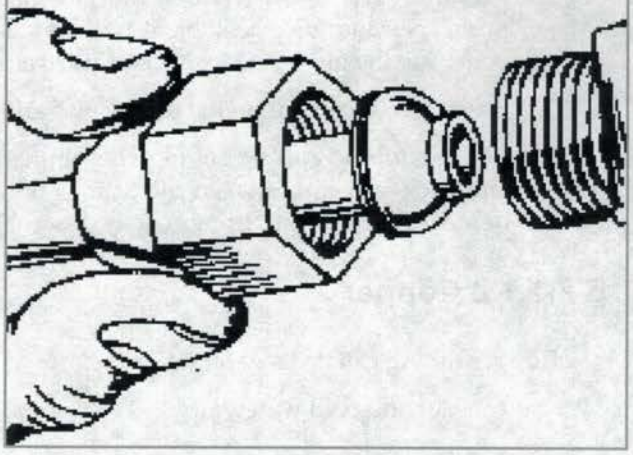
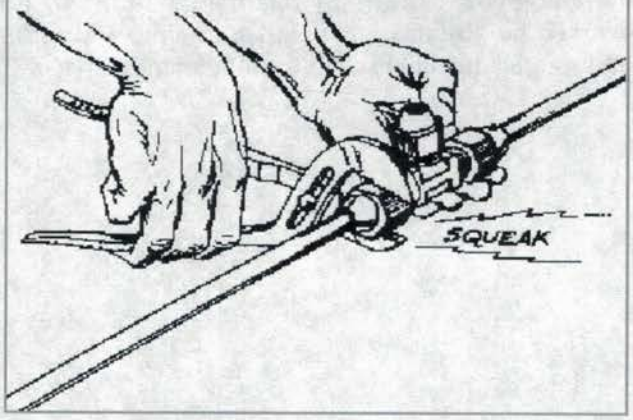
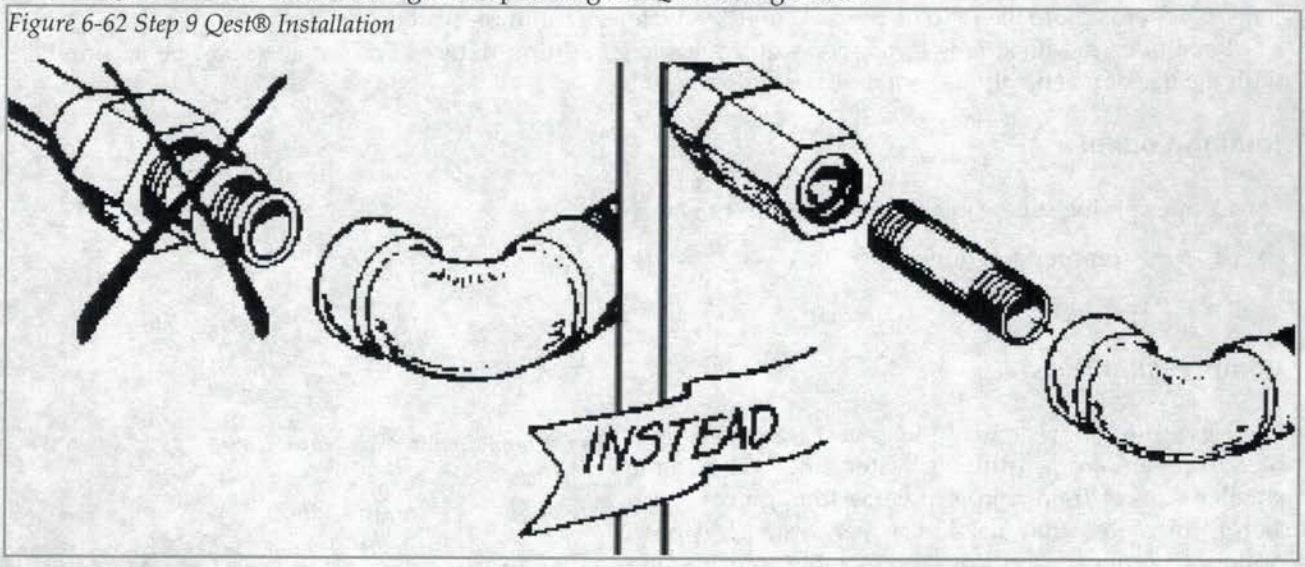


Figure 6-61 Step 8 Qest® Installation



9. Never assemble male Qest® Acetal threads into female fittings. Install a metal nipple for use with Qest® Acetal female fittings incorporating the Qest® Magic-Seal.

Figure 6-62 Step 9 Qest® Installation



PEX/Polybutylene (PB) Flare Installation Procedure

PEX/Polybutylene (PB) can be flared using the same procedures as copper. See *"Flaring Tools" on page 6-37*

CPVC Installation Procedure

Rigid piping such as CPVC is assembled with plastic pipe cement.

1. Cut tubing square using a pipe-cutting tool or miter saw.
2. Remove burrs and ridges from the cut end using a deburring or chamfering tool.
3. Check the dry fit of the fitting. The tubing must enter the fitting, but it should not be so loose that it will fall off.

4. Brush a cleaner or primer over the pipe end and a light coat on the fitting socket and let it dry. This cuts the gloss finish from the surface of the plastic and cleans off any foreign material. With the primer/cleaner on, the solvent will be able to actually melt the plastic together instead of having to penetrate the gloss surface and act as a cement.
5. Brush CPVC cement on the tubing end and a light coat on the fitting socket.
6. Join the tubing and fitting together immediately[1] and give a 1/4 turn. By rotating the fitting 1/4 turn and back, any air between the fittings will be worked out. By using the marks on pipes and fittings described above, the fittings can be assembled and rotated quickly back to the alignment marks.

6-2.1.1.2 Copper

Copper tubing can be used for:

- Hot and cold water supplies
- Waste systems
- Vent systems
- Heating and cooling applications

Copper is a very beneficial material, because it is readily available, easy to fabricate, strong, almost non-corrosive, and capable of withstanding extreme temperatures. However, it is never used for RV drainage systems. Copper is more likely to be used for an RV's water distribution system.

Repairs or modifications to copper water lines (e.g., adding fixtures and devices) can be accomplished with the use of plastic piping as a replacement material.

Joining Copper

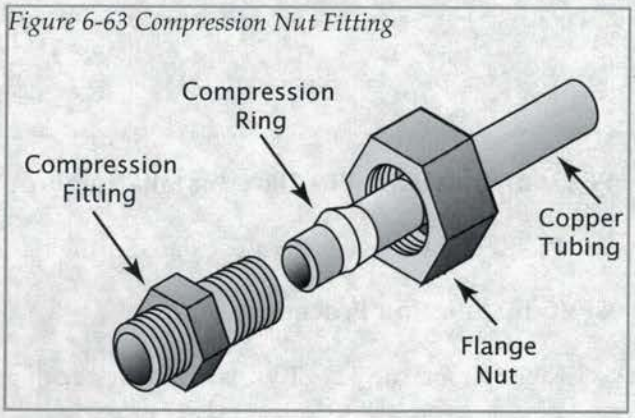
Copper piping can be joined in two different ways:

- Compression nuts
- Flaring

Compression Nuts

Figure 6-63 shows one of the easiest ways to assemble or repair copper tubing water lines (and some smaller sizes of rigid copper pipe). Although compression fittings are rarely used on water systems, it is an option. In order to perform the assembly/repair some soft copper tubing, a brass compression ring, a nut, and a fitting are needed.

Figure 6-63 Compression Nut Fitting



Compression fittings are designed to fit many different sizes of tubing, from 1/8 in. up to 5/8 in., in the RV industry. The compression fittings are made of brass, which is slightly harder than the copper tubing. The compression ring is designed to be put on the tubing after the compression nut and then inserted into the fitting.

The nut has a female thread in it and a machined surface inside that will conform to the surface of the compression ring. It has a six-sided nut fitting on its outside. The fitting that the nut and ring fit into has a male

1. "Immediately " means there is no time to waste assembling these fittings, as the solvent will bond very quickly. Be aware of the quick cure time, especially when it is warm outside, as the cure time accelerates with heat.

thread on the outside along with a six-sided fitting for a wrench on the outside. Inside, it is machined to fit the copper tubing securely, in addition to a surface on the inside of the tube to fit the other side of the ring.

The assembly is held inside the fitting as the nut is threaded on the fitting and the nut is tightened. As the nut is tightened on the fitting, the ring is compressed onto the copper tubing and formed to the nut and fitting. For best results, the technician should use flare nut or box wrenches. These wrenches are designed to be applied to a hex fitting such as a nut with five sides of the wrench fitting tight on the nut. This type of wrench applies even pressure against the soft brass and reduces the risk of the nut or fittings "rounding off." Using an open-end wrench may only apply pressure to two sides of the nut and cause it to distort and strip. Adjustable wrenches are the last resort and should be avoided, as they are bulky, and the jaws can be easily opened accidentally, causing a "rounding off" of the nut or fitting.

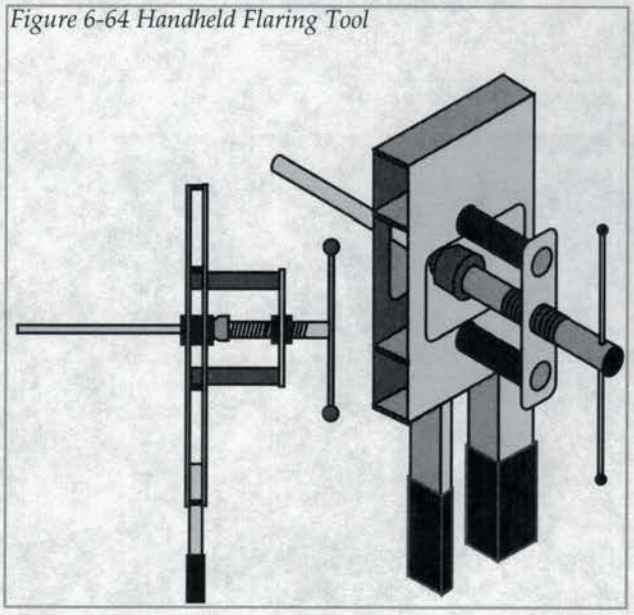
Generally, compression fittings seen in the RV's water distribution system will be limited to those that are an integral part of an appliance or device. While compression fittings are easy to use, they can be tricky and could lose their ability to completely seal once a tight joint has been loosened. To help ensure a good compression joint, be sure that the copper tube does not extend into the compression nut. If the tube "bottoms out" in the compression nut, the compression ring may clamp the tubing before seating into the beveled edge of the compression nut.

NOTE: Also, remember that the use of compression fittings is prohibited on propane copper tubing and is only to be considered for use with water system tubing.

Flaring Tools

Flexible copper tubing can be assembled by flaring the end of the tubing in a handheld flaring tool, an example of which is shown in *Figure 6-64*. The block, via pressure from a turned-down "wedge," flares the end of the tubing to match the fitting it joins.

Figure 6-64 Handheld Flaring Tool



Some working tips:

1. Select a tubing cutter that is the appropriate fit for the tubing. Next place the tubing inside the cutter and rollers, then proceed to turn the knob until it makes contact with the tubing. Begin to rotating the cutter around the tubing while simultaneously turning the knob, which will apply more pressure with each revolution. Be careful not to apply too much pressure, because it will distort the tubing. Just tighten about one-eighth to one-fourth turn of the knob with each revolution around the tubing. The amount of pressure applied should be enough to feel resistance on the knob but not to force it. The cut will be smooth, and the tubing will retain its round form. After cutting through, the tubing will have a rounded outer edge and a raw lip or ridge on the inside diameter. Larger tubing cutters will usually have a file or scraper built into them. Rotate the file or scraper out and place it inside the tubing, then rotate it around until the lip or ridge is gone.

Figure 6-65 Tube Cutter

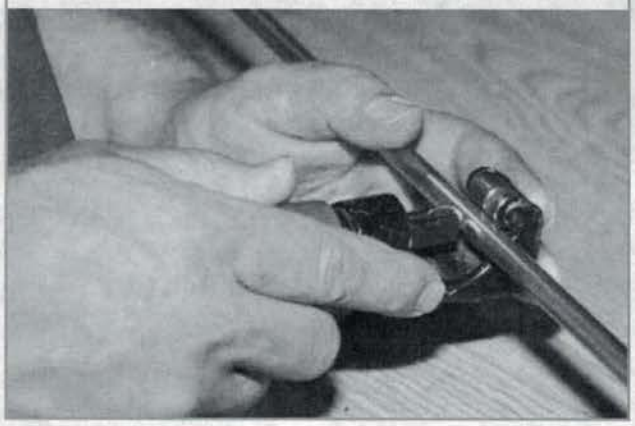


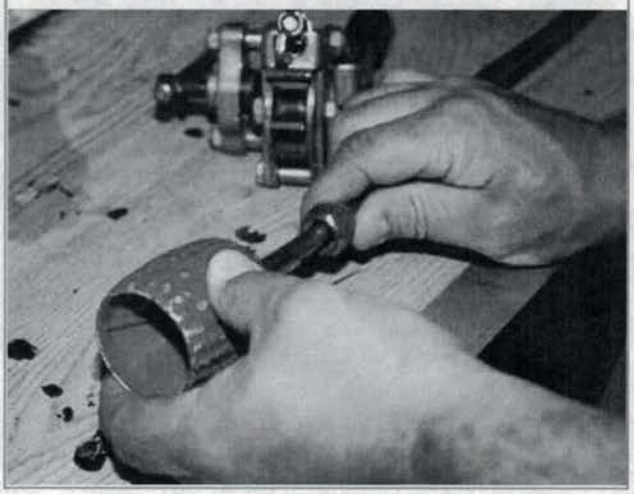
Figure 6-66 Tube Cutter with Deburring Tool

NOTE: This is extremely important because, if it is not removed, a good flare cannot be achieved.

The lip or ridge will "roll over" inside the flare, and a good surface contact between the flare nut and fittings cannot be accomplished. If the cutter does not have a file/scraper, a small, fine file can be used. File inside the tubing until the lip or ridge is gone. When removing the lip or ridge, it is a good practice to hold the tube opening toward the ground so the shavings fall to the ground instead of staying inside the tubing. A flat file may be used to ensure a flat surface, but if it is, be sure to file the inside of the tube again.

Figure 6-67 Deburring Tool

Figure 6-68 Using Deburring Tool



2. Position and lock the tubing in the flaring tool block. Insert the tubing in the jaws, position it low in the jaws, and clamp the handles together; this will lock the tubing in the tool.

NOTE: The position of the tubing should be in accordance with the recommendation of the tool manufacturer. Too small a flare will provide a poor seal. Too large a flare may result in a crack.

Make sure both jaws are the same size, as multiple sizes are available by rotating the jaws around in the block. They are identified by numbers such as 3/8, 1/4, and 3/16 on each opening. Do not forget to put the flare nut on the tubing before flaring. If forgotten, the tubing may have to be cut and reflared after the nut is put on correctly.

Figure 6-69 Installing Flare Nut

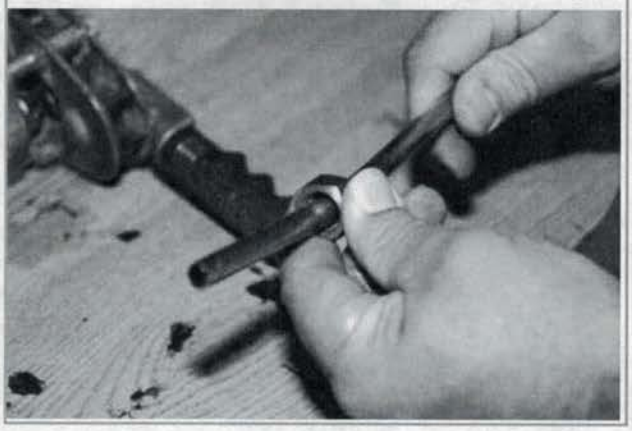
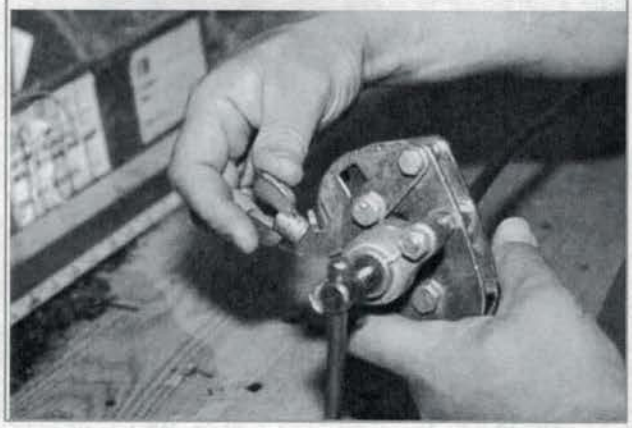


Figure 6-70 Flare Tool Use



3. Turn down the flaring tool wedge by rotating the handle clockwise, and it will start the flare on the end of the tube.

Figure 6-71 Making Flare

4. Loosen the handle to back off the wedge on the tubing. Open the handles to reposition the tubing in the block so it is flush with the surrounding surface of the flaring block. Close the handles again to clamp the tubing.
5. Tighten the flaring tool to complete the flare. The flare has to be perfectly formed in order to produce a watertight connection. Attempting to make the flare all at once can "bell" the flare. Once using the block has been mastered, flaring tubing can be done in one operation. Until then, insert the copper tube into the block a little at a time, flaring at each step until the flare is the appropriate size. Once the flare is complete, inspect it carefully for any deformity or defect that could cause or lead to a leak. *Figure 6-72* shows examples of correct and incorrect flares. Look closely to see if hairline cracks are present, usually extending from the outside edge of the flare towards the inside of the pipe. If any of these defects are present, cut the flare off the end of the pipe and begin again.
6. Never use sealants such as pipe dope or thread tape (Teflon® tape) on flare fittings. The copper forms a tight seal against the "nose" of a flare fitting upon tightening. The use of sealants can prevent a proper seal.

Figure 6-72 Flares

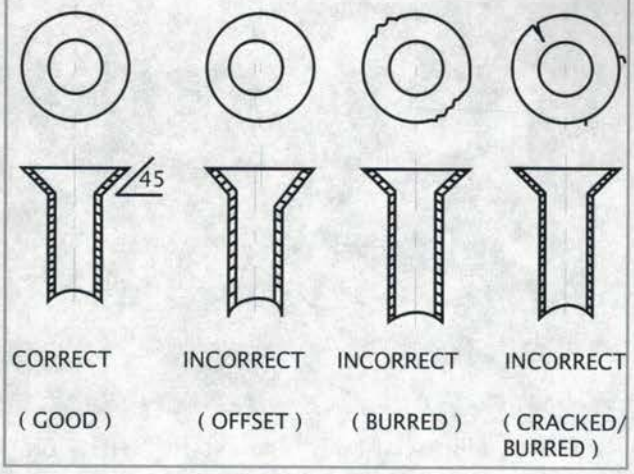
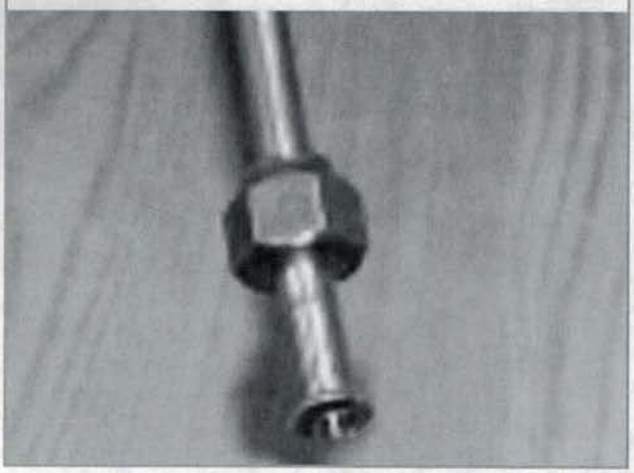


Figure 6-73 Flare Nut and Tubing



6-2.1.1.3 Fittings

Brass

Brass fittings are used extensively in the water system because of the advantages that brass offers, such as its noncorrosive nature. Brass fittings are not required to be listed, and listing marks will not usually be found. Fitting manufacturers are beginning to mark each fitting, at least to identify its manufacturer. It is not uncommon to find brass fittings without any marks. This is acceptable, since brass is a material that is known to be acceptable for use with potable water.

Plastic

The PB compression fitting consists of a nut, a stainless steel or brass insert, and a sealing washer that makes a watertight connection with the fitting. When the nut is screwed onto the fitting, the insert and washer compress against each other, making a tight and leak-free connection. If the need arises to combine PB and copper, the compression fittings used for PB can also be used on the copper tubing.

Fittings (45° and 90° elbows, straight couplings, tees, and so on) are used to assemble pipe, and the pipe is recessed into these fittings approximately 1/2 to 5/8 in. (12.7 to 15.88 mm). Remember that there must be enough piping to match the pipe run, plus the extra pipe needed for the fittings at each end or throughout the run.

Most fittings have a shoulder inside the fitting. The end of the pipe fits tightly against this shoulder when it is assembled. Because of this fit, the pipe must be cut square against the shoulder. Use a tube cutter or a hacksaw to cut pipe. If a hacksaw is chosen, use a miter box with the saw to make sure that the cuts are square. The tubing must be deburred after cutting.

If the piping will go through a framing member or wall, drill the hole a little larger than normal so as to allow room for expansion and contraction. Work with the same type pipe and fittings if possible. With plastic, try to stay with exactly the same brand. One brand may have a slightly different formula from another. However, if the products meet American Society of Testing and Materials (ASTM) standards and local codes, it is possible to use different manufacturers' pipe and fittings.

If solvent-welded plastic pipe and fittings are being used, they must be cleaned with a plastic pipe cleaner before the pipe cement is applied. The cleaner removes grease or oil left by human contact. Remember that grease or oil can cause a poorly cemented connection or "weld."

Listed Sealants

Sealants used in the water distribution system must be listed and approved for use with potable water. The evidence of listing and acceptability for use with potable water will normally be found on the label of the sealant container. Sealants should not be used on PB or PEX tubing but may be used at other places in the water distribution system. An example of a location where an approved sealant, such as silicone, could be used would be at the gravity fill hose connection to the storage tank. Always check sealants to ensure that they are approved for use with potable water, and use the sealants according to their specific instructions. Silicone sealants are generally acceptable for use with potable water, although the tube of sealant may not specifically reference potable water. When in doubt, don't use the sealant.

6-2.1.2 System Sanitary Considerations and Protection

6-2.1.2.1 Backflow Prevention

A means for backflow prevention is required in the water distribution system to keep water from flowing in an undesirable direction. Basically, backflow prevention devices installed in the water distribution system prevent contaminated water from inadvertently entering the potable water supply and protect non-pressure components from the high pressures associated with the city water source of water.

Backflow prevention devices in RVs consist primarily of either check valves or vacuum breakers. Check valves are mechanical devices that allow water flow in only one direction by mechanical means. The mechanism is spring activated. These are present at the city water service connections as an integral part of most water pumps, or they can be separate valves installed anywhere in the piping system.

Check Valves

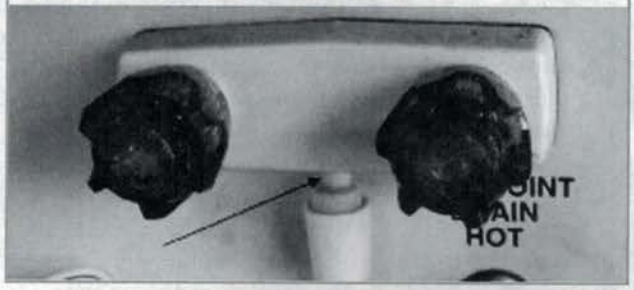
A check valve must be located at every city water service connection if the water distribution system has a non-pressurized water tank connected to the same system as the city water connection. The check valve is used to protect the city water system from contamination by backflow of water from the RV's water system. It also prevents water from running out when the city water is disconnected. Check valves are required to be either integral with or immediately adjacent to any city water service connection.

The check valves allow the city water to work without backfeeding the water pump or blowing out the valving in a water pump. The water pump may have a check valve built into it. The water pump will apply pressure to the city water inlet, and the check valve is necessary to stop leaking from the city water fitting. On some older models, the city water inlet may just be a fitting, and a separate check valve will be included in the piping inside the system.

The check valves of city water service connections should never be disabled. Visually check for the presence of a spring at the city water service connection inlet. Replace any defective check valve by replacing the city water service connection assembly. (See *"City Water Service Connection and Backflow Prevention" on page 6-59.*)

Vacuum Breakers

Figure 6-74 Shower Vacuum Breaker at Hose Connection



Vacuum breakers are devices that prevent backflow by letting air into the system, thus preventing siphoning of potentially contaminated water into the freshwater supply. These are commonly present as screw-on adapters for 3/4 in. exterior hose connections, or as a special fitting or D-ring at the point where a shower hose connects to the system.

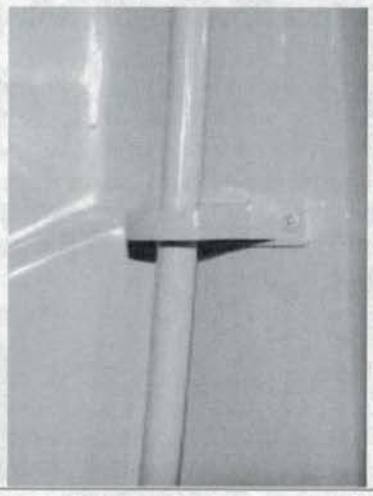
Vacuum breakers are used in the freshwater system to provide backflow protection at locations where a hose or hose connections could cause a cross-connection to the RV's wastewater system. An example of this

would be where a shower hose is capable of reaching water in the tub or sink. In these cases, a vacuum breaker is often provided at the shower hose to faucet connection, or it could be an integral part of the faucet. The external vacuum breakers attached to the faucet will let a little water run out of the system after the shower hose is used. This "leak" is a common way to see if a vacuum breaker is working. If water leaks out of the vacuum breaker, air is in the shower hose, and water could not be siphoned out of a nearby fixture if the shower hose were laid in it. This siphoning would happen only if the showerhead were immersed in a filled sink or toilet and if a decrease in the city water system pressure occurred at the same time. The vacuum breaker should not be replaced. There is a fitting, referred to as a *D-spud,* that has the same size and shape body as the vacuum breaker. The D-spud, however, does not have the internal airway that is present in the vacuum breaker. While the use of the D-spud will eliminate the leakage at the lavatory, the safety protection given by the vacuum breaker is lost.

D-Rings

If the consumer insists that the "leakage" be stopped and forces replacement of the vacuum breaker with a D-spud, be sure to install a D-ring so the showerhead cannot reach a potential source of contamination such as an adjacent sink or fixture. The D-ring should have the showerhead threaded through it and the D-ring screwed to the shower wall in a location that restricts the movement range of the showerhead. Using the D-ring will also ensure safety where a vacuum breaker cannot be installed.

Figure 6-75 D-Ring



6-2.1.3 Freshwater Storage Tanks

6-2.1.3.1 Types

There are two types of water storage tanks for potable water. These are the non-pressure and pressure tanks. Pressure tanks are not very common on today's RVs; most are the non-pressure type. Let's compare the two types of tanks.

Non-Pressure Tanks

Non-pressurized storage tanks are by far the most common found in RV's today. These tanks are usually made of a lightweight, durable plastic. Non-pressure tanks are either made with a polyethylene or ABS plastic. The majority of RVs tanks today consist of polyethylene. Polyethylene tanks are made by a "rotocast" procedure. Small chips of granules of plastic are poured into an aluminum mold. The tanks are usually milky white in color or pale blue or aqua. The amount of plastic used is determined by the surface area of the mold and the thickness desired for the tank.

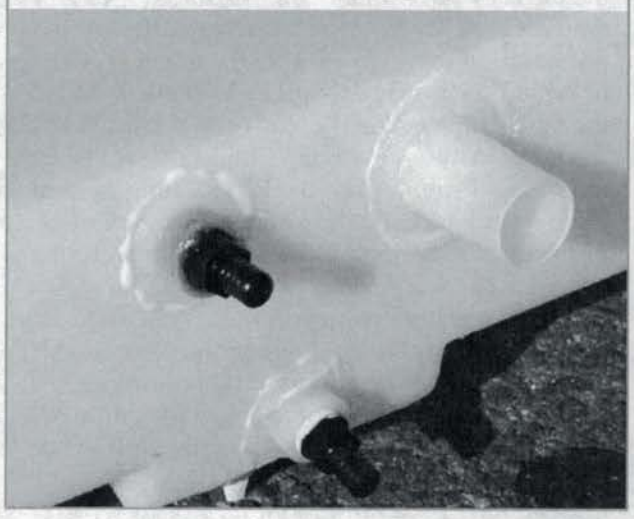
These tanks are constructed by heating the plastic inside the mold of an oven, while being rotated in all directions. The plastic granules are heated until the plastic takes a molten form. As the tank rotates, the molten plastic flows all around the mold evenly, then it is brought out of the oven and continues to rotate in the open air until the plastic cools to ambient temperature. It is then removed from the mold, creating a one-piece, seamless tank. The tank is then tested for leaks by submerging it into a water tank. If air bubbles are present, this is an indication that there are leaks in the tank.

This tank will typically have a minimum wall thickness of 1/8 in. (3.175 mm). The corners of the tank will be thicker, as the plastic tends to round out the inside corners. This type of construction makes for a durable, leak-proof tank. The fittings for the RV system are "spun" on. A hole is drilled into the tank corresponding to the required fitting. The fitting is placed into a special adaptor attached to a 25,000 rpm router. The fitting is placed on the hole in the tank, and the router is turned on until the fitting and the tank melt together. The router is held there for several seconds until the plastic cools, and then is removed, causing the fitting to

become permanent. If a fitting cracks or leaks, it can be cut off and a new one can be spun on over the base of the previous fitting.

Heat is the only way to permanently repair a polyethylene tank. Nothing will stick to it permanently. Fiberglass, caulkings such as silicone, and patch kits will temporarily fix the tank, but nothing will bond to it. Patching this type of tank must take into consideration where the crack or hole is located. A hole is usually a sign of a puncture and can be repaired either by welding or by covering with a spin patch. Cracks, on the other hand, are a sign of stress or pressure, usually caused by poor installation or mounting.

Figure 6-76 Weld Fittings



ABS tanks are also available, but they are not used as often. ABS tanks are built in pieces and cemented together. The main body is typically heated in a flat sheet form and put onto a mold shaped for the tank. It is vacuum formed over the mold, creating the shape of the main body. A top, which is usually flat, is cemented onto the body, forming a tank. The advantage of this tank is that it can be repaired easily with ABS cement and some ABS patching material. An old ABS tank can be salvaged for repair pieces. One disadvantage is that it is relatively thin, so proper installation is very important.

All tanks will flex when water is added to them. Water weighs about 8-1/4 lb (3.742 kg) per U.S. gallon; therefore a 40 gal tank will weigh 330 lb (149.7 kg) when full. Add to this pressure the fact that the tank is moving with the motion of the RV. Pressures will, therefore, occur that are not constant. Stopping or starting the RV will shift the water from one end to the other and back. If the tank is not supported or secured properly, a stress crack could develop.

Several factors must be taken into consideration when repairing these cracks. The main cause for repair is aging of the tank. With time, plastics become more brittle, making plastic welding or repair impractical. If the tank is newer and still pliable, an irregularity in the floor or poor support for fastening usually is involved. Some tanks, for example, have a portion that will sit on the floor and on a wheel well. If the portion supported by the wheel well does not fit correctly, or the wheel well sags and the weight of the tank is only supported by itself, there is a good chance that a stress crack will develop. Make sure the tank is properly secured and supported once any repairs have been made and it has been reinstalled. If not, the chances of the tank failing again are highly probable.

Labor costs should also be considered when repairing a tank that has suffered stress cracks. The tank will usually need to be removed because, in most cases, the damage will be on or near the bottom of the tank. The labor required when removing and replacing the tank may be extensive, depending on the design of the unit. If a manufacturer repairs the crack, it will not usually guarantee the repair. If the shop makes the repair, there is the question of how long it can be guaranteed. Consideration must be given to the cost of labor to repair and replace the tank and weld with no guarantee versus removing the old tank and replacing it with a new one. Labor costs are usually quite high, depending on how the tank is installed, so a guarantee is important to consider.

Maintenance consists of keeping the tank fresh through the sanitizing procedures described in *"Instructions for Disinfection of Potable Water Systems on Recreation Vehicles" on page 6-44.*

The water system should also be drained and have potable antifreeze (nontoxic) installed during cold winter months. This prevents damage to the system.

The most difficult procedure involving non-pressurized water tank repair is the removal of the tank itself. Some repairs can be made to the tank while it is installed on the RV, but in most cases the tank must be removed.

Pressure Tanks

Pressurized water storage tanks are typically round, available in multiple lengths, and constructed of metal. They have an air compressor and/or a connection for an external air pressure source. RVs with these systems are easy to identify, because they have a pressure regulator, gauge, and an air inlet valve (similar to a tire inflation valve) integral to the water service connection. These metal tanks must be removed and repaired or replaced if any leak is present. These metal tanks are typically made of galvanized steel, and if leaks occur, the tank's fill, vent, and outlet fittings should be checked. Usually, the tank fittings are brass and soldered into the tanks. Any stress on the fittings due to the tank's movement could lead to leaks. The best repair method is removing the tank from the RV, locating the leakage point, thoroughly drying the leakage area and resoldering the fittings. On older water tanks, sediment and rust could collect in the bottom, leading to other related problems. Properly sanitize the tank in accordance with the following instructions as directed by *NFPA 1192* or *CSA Z240*.

Loss of water pressure in these systems is usually a result of depleted air pressure in the system. Check the pressure gauge and repressurize the system with compressed air as necessary. Check all fittings for leaks if the pressure seems to deplete faster than usual. If there are leaks where there is water, it will show moisture. If air pressure is leaking, it could be from the pump or its air line to the top of the tank, the fill neck, air fitting, cap, or connections. Check for leaks carefully with a leak detector such as soapy water or children's bubble solution.

Instructions for Disinfection of Potable Water Systems on Recreation Vehicles

This procedure is approved by the U.S. Public Health Service.

To ensure complete disinfection of the potable water system, it is recommended that the following procedures be followed on a new system, one that has not been used for a period of time, or one that may have become contaminated. This procedure is also recommended before long periods of storage such as during the winter.

1. Prepare a chlorine solution using 1 U.S. gal (4 L) of water and 1/4 cup (60 mL) of household bleach (sodium hypochlorite solution). With the tank empty, pour the chlorine solution into the tank. Use 1 U.S. gal (4 L) solution for each 15 U.S. gal (60 L) of tank capacity. This procedure will result in a residual chlorine concentration of 50 parts per million (ppm) in the water system. If a 100-ppm concentration is required, as discussed in item 3, use 1/2 cup (120 mL) of household bleach with 1 U.S. gal (4 L) of water to prepare the chlorine solution. One U.S. gal (4 L) of the solution should be used for each 15 U.S. gal (60 L) of tank capacity.
2. Complete filling the tank with potable water. Open each faucet and run the water until a distinct odor of chlorine can be detected in the water discharged. Do not forget the hot water taps.
3. Allow the system to stand for at least 4 hours when disinfecting with 50-ppm residual chlorine. If a shorter time period is desired, then a 100-ppm chlorine concentration should be permitted to stand in the system for at least 1 hr.
4. Drain and flush with potable water.

6-2.1.3.2 Plastic Tank Repair

Water fills for tanks usually consist of a plastic hose connected with hose clamps to the water tank fill inlet and the back of the fill opening mounted on the RV's sidewall. The length of a water fill hose is not addressed in the RV standard, but it should be as short as practical. Since the fill hose depends on gravity, the fill hose has to be routed so the water runs into the tank. On long fill hose runs, the hose should be supported appropriately. The hose must be installed so that the hose smoothly descends to the tank fill fitting with no sags. Any sags in the hose will accumulate water, creating a potentially unsanitary condition. Also, in this case, the water must push past the sitting water in the sag, and the filling process will be slowed. Supporting the hose with plumber's tape or supports is important on long runs of the hose.

Leaks can sometimes occur at the connection of the fill hose to the water tank. This repair can usually be performed without removing the tank. Remove the hose connection, remove any old sealant, and apply a coat of sealant (approved and marked on the dispenser for use with potable water). Reconnect the hose and tighten the hose clamp. Ensure that the hose is not kinked or routed so as to create stress at the point of repair. This same procedure can be used to repair a leak at the hose connection at the gravity fill inlet.

Epoxy Resin/Fiberglass Patch for Rotocast Tanks

1. Drain the tank so the cracked area is dry. Remove the tank if necessary.
2. Drill a small hole at each end of the crack.
3. Sand the area around the crack.
4. Cut a fiberglass patch 1 to 2 in. (25.4 to 50.8 mm) larger than the crack.
5. Mix the epoxy resin and catalyst according to the instructions.
6. Spread a layer of epoxy resin over the sanded area.
7. Lay the patch over the resin and pat the fiberglass until soaked with resin.
8. Add resin on top of the patch until it is glossy and the fiberglass cloth is covered. (The resin will be tacky in 20 min and fully hardened in a few hours.)
9. Fill the tank and inspect the area for leakage.

Polyethylene Tank Repair

Polyethylene tanks can be temporarily repaired with aftermarket patch kits, but welding is the only viable method of repair. Refer to *"Welding Plastic" on page 6-46.*

ABS Tank Repair

ABS cement and liquid ABS solvent cements were developed to fit virtually any application. Where the area to be repaired is extremely small, it may be quicker to make a satisfactory cement by dissolving ABS pellets in a solvent such as methyl ethyl ketone or methylene chloride. This mixture is then applied to the damaged area with a squeeze bottle, putty knife, spatula, trowel, or similar applicator. Upon solvent evaporation, the hard durable solids remaining can easily be shaped to the product's contour by sanding or filing. ABS cement and liquid ABS adhesives are not recommended for highly stressed areas, on the thin-walled parts, or for patching holes greater than 1/4 in. dia.

1. Drain the tank so the cracked area is dry. Remove the tank if necessary.
2. Drill a small hole at each end of the crack.
3. Sand the area around the crack.
4. Cut a fiberglass patch 1 to 2 in. (25.4 to 50.8 mm) larger than the crack.
5. Clean the area to be repaired with cleaner solvent or primer.
6. Spread a layer of ABS cement or liquid ABS over the sanded area.
7. Lay the patch over the ABS cement or liquid ABS and bat the fiberglass until soaked with solvent.
8. Lay a second, slightly larger fiberglass patch over the first patch.
9. Add ABS cement or liquid ABS on top of the patch until it is glossy and the fiberglass cloth is covered. (The ABS cement or liquid ABS will be tacky in minutes and fully hardened shortly thereafter.)

Welding Plastic

If welding is necessary to make a repair, secure a plastic welding unit. The plastic welding unit will consist of a heating element with various types of tips for heating the base material to be repaired, and an air regulator and pressure gauge to control heated air. Welding rods should be selected according to the type of material to be welded.

Table 6-2 shows welding rod standards for welding different plastics.

Table 6-2 Welding Rod Standards

Material	Polyethylene	ABS
Welding rod color code	Brown	Blue
Welding temp.	550°F (228°C)	500°F (260°C)
Forming temp.	300°F (149°C)	300°F (149°C)
Welding gas	Air	Air
Recommended pressure (psi)	3	3

How to Achieve Quality Plastic Welds

A good final weld is easy to achieve with either a round or high-speed tip. A good weld cannot be pulled apart even when hot, and the final weld can be stronger than the surrounding part.

1. Small beads of "juicing" should form along each side of the weld where the rod meets the base material.
2. The welding rod should hold its basic round shape.
3. Neither the rod nor the base material should char or discolor.
4. The rod should never be stretched over the weld. In other words, the length of the rod should match that of the weld.
5. Clean air or nitrogen should be used, not oxygen or other flammable gases.
6. Proper welding methods and working with the tacking and the round and high-speed tips should be practiced before trying to repair a damaged part.

Compare the plastic welding results with *Figures 6-78*, *6-79*, and *6-80*.

Figure 6-77 Welding Rod with Heat Gun

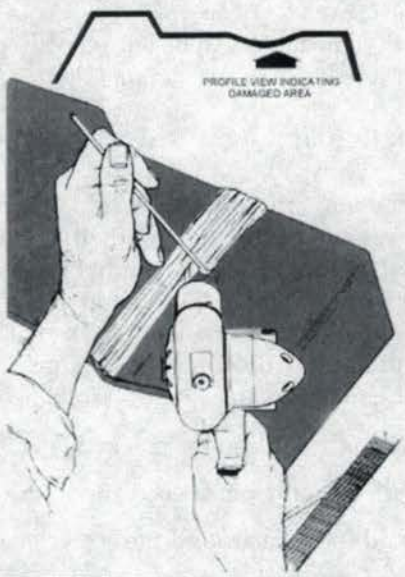


Figure 6-78 No Bond (Weld Can Be Pulled Apart)

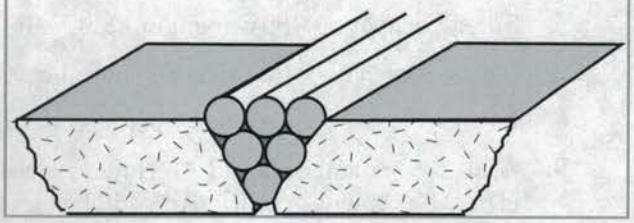


Figure 6-79 Proper Weld

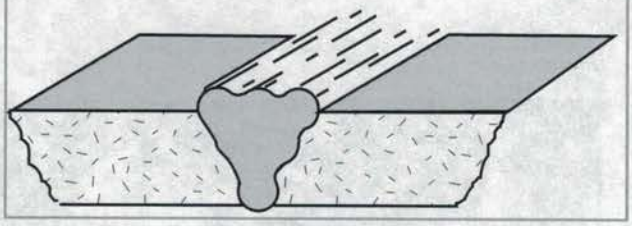
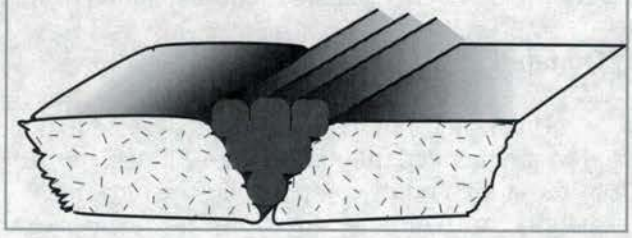


Figure 6-80 Burned Weld and Material Charred (Weak Weld)



NOTE: The operating instructions for the electric plastic welder and any accessories should be followed carefully. This will help achieve a successful weld and protect the equipment.

NOTE: A plastic welding training video is available from Bunzer Consulting, P.O. Box 2074, El Cajon, CA 92021. Send check or money order (U.S. Funds Only) for $24.95 plus $6.00 S/H.

6-2.1.3.3 Vents

Freshwater storage tanks must have an air vent. This vent allows air to escape from the tank when displaced by water during the filling process. The air vent on the storage tank will usually be connected by a piece of plastic tubing routed through the sidewall or floor. This vent could also be connected to a small opening on the gravity water fill inlet.

A water tank will fill slowly, "burp" water back out, or not fill at all if the vent hose is clogged or restricted. When filling the tank is a problem, it is usually because the hose has become kinked, bent, or plugged, not allowing air to pass. The problem can be fixed by shortening the hose to remove the kink or by replacing the hose if it is too short. Sometimes bees, spiders, or insects can nest in the vent hose. This, too, will cause a restriction that could slow or stop the filling process.

6-2.1.3.4 Drains

Water storage tanks must also be equipped with a low point drain to allow the tank to be completely emptied by gravity. This is helpful when sanitizing or winterizing the water distribution system. This drain may be through the sidewall with a draincock, or it may pass through the floor of the coach. If the drain goes through the floor, the valve may be outside with the drain hose, or it may be inside, usually at the tank drain outlet or above the floor just before the drain line drops through the floor.

6-2.1.4 Pumps

6-2.1.4.1 Water

The water pump is the heart of the water system. Pumps come in many sizes and are made by many different manufacturers. This discussion is intended to be generic in nature. Differences in pumps are possible, and technicians should carefully read individual service manuals before repairing or replacing any water pump.

Hand Pump and Manual Electrical Pumps

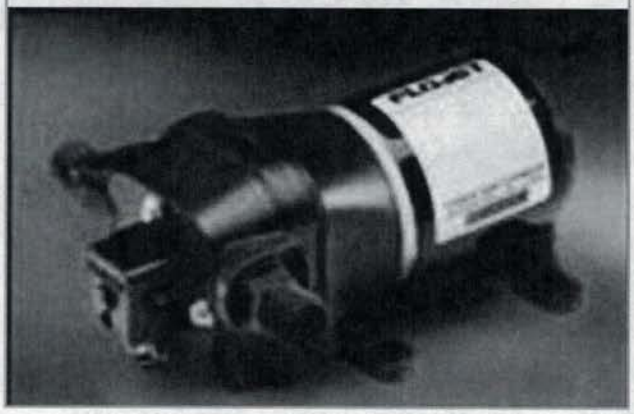
These water pumps are used on small units such as folding camping trailers and truck campers. With hand pumps only, water is drawn from the storage tank by a simple pumping motion. These pumps are not usually repairable, thereby mandating replacement if rendered inoperable.

Hand pumps/manual electrical pumps offer two modes of operation. The hand pump action works like any other hand pump, drawing the water from the system through a pumping action. The other mode offers water flow by positioning the handle differently, which activates a small electric pump that draws water from the storage tank.

Both of these pumps have been used in conjunction with city water inlet systems. However, there may be city water systems that are totally separated from the pump.

Demand

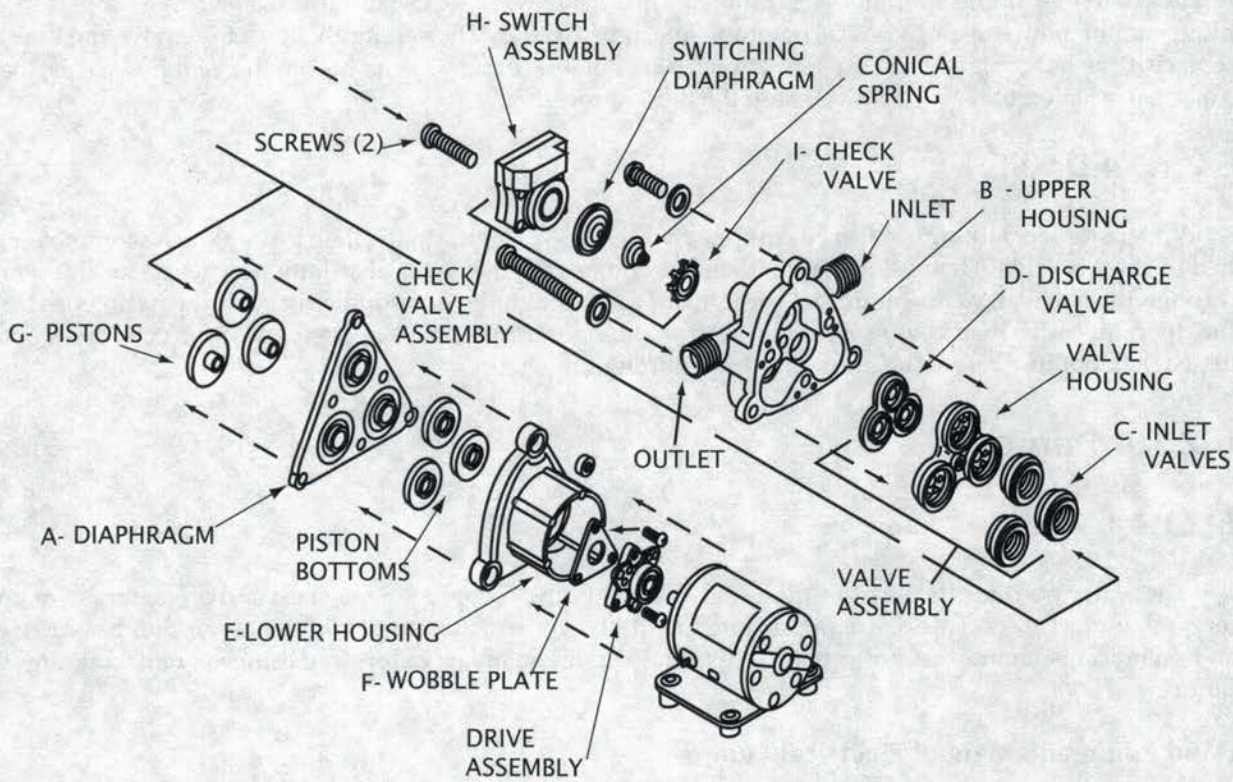
Figure 6-81 Flojet Pump



The water pump in a demand system is a diaphragm-operated pump. *Figure 6-81* depicts a typical water pump and its components. The movement of the diaphragm (A) in one direction draws water from the freshwater tank into what is called an *upper housing* (B) through the inlet valve (C). The diaphragm then moves in the opposite direction, pushing the water in the upper housing into the pipes or tubing of the water system through the discharge valves (D) to the fixtures, satisfying the demand on the system.

Water pumps are assembled using a number of different components. The major components of the water pump consist of the motor, the lower housing (E), the upper housing (B), a check valve (I), and a switch assembly (H).

Figure 6-82 SHURflo® Water Pump



6-2.1.4.2 Motor

A water pump has a permanent magnet motor powerful enough to prime the onboard water system. A typical water pump can achieve a water pressure of 40 psi or more. At this pressure, the current drawn by the motor is usually 3 to 10 A. Water pump motors in RVs are protected from overload damage by an internal thermal circuit breaker. Thermal circuit breakers stop the motor to keep it from overheating and allow the

motor to cool. The thermal circuit breaker is made of bimetal. As the amperage and heat of the motor increase the temperature in the motor housing, the metal will distort, opening the contacts, and current will be interrupted, thereby stopping the motor. After the motor has cooled sufficiently, the pump will restart automatically upon demand. These pumps are also protected from overpressure by a pressure-sensitive microswitch, usually designed to come on at 25 to 28 psi and shut off at 40 to 45 psi. Some are adjustable.

Drive Assembly

The lower housing (E) of the water pump is located next to the motor. The lower housing is that portion of the water pump in which the motor's rotary output is converted to reciprocal (up-and-down or push-pull) motion. The wobbler converts this motion and is typically a cam-driven ball bearing assembly.

Upper Housing

The upper housing (B) is where the actual pumping takes place. This housing also contains the inlet (C) and discharge (D) valves. There are three "pistons," including a rubber diaphragm (A) that isolates the lower housing and motor from water. Each piston moves less than 1/8 in. (3.175 mm) from its top to bottom stroke. "Valving" is a process that uses a rubber inlet valve that flexes, allowing inlet water to be drawn in on the downstroke, and closes to direct the pressurized water to the outlet side of the pump. Because of the pump's short stroke, the diaphragm lasts a long time. Since there are three "pumps" in this pump, the pulsations from it are greatly diminished at the fixture.

Switch Assembly

A switch assembly (H) contains a shutoff switch diaphragm that retains the check valve assembly in the upper housing. When the pump is on but no water is being drawn, the pump runs only briefly to pressurize the lines. When the line pressure reaches about 40 psi, the motor shuts off until a fixture is opened. This reduces the pressure in the lines and places a "demand" on the system.

If several fixtures are in use at one time or a heavy demand is placed on the system, the motor will run continuously. Otherwise, it may run intermittently, indicating that the pump is building the pressure back up to 40 psi faster than the water is flowing. This is known as *cycling* and is a normal function of the water pump. However, extended cycling could be an indication of a problem in the system, such as a leak, if all demands are turned off. In the case of very quick cycling, there may be an actual restriction in the water line. In the illustration of the pump in *Figure 6-82*, a switch assembly (H) contains both a shutoff switch and a check valve. This is not necessarily the same on all pumps; in fact, most will vary from this design.

The demand system pressurizes from the pump. When the pump is turned on and all the fixtures are closed, the pump will run and pressurize the system. As it runs and pressurizes the system, the pressure builds up because the water cannot release or compress. The pressure switch is opened by a plunger that is compressing a spring that opposes its movement, and the plunger pushes the switch, opening the electrical circuit. If the pump runs excessively or intermittently, there may be air in the lines, and the pump is compressing the air. All fixtures should be opened, one at a time, to remove air from the lines until the water runs freely. Once all the air has been removed and the pump has pressurized the system to 40 psi or more, the pump will shut down. When a fixture is opened and water is allowed to flow, the pressure quickly drops, and the plunger, while pushing against the switch, will be overcome by the spring tension and will back off from the plunger. This closes the circuit and restarts the motor, causing another cycle until the fixtures are closed and the system repressurizes. The term *demand* comes from the fact that the system is pressurized and, if water is drawn off, the system demands the pump to be turned back on to supply pressure and water flow.

Check Valve

The check valve (I) prevents high-pressure city water from backing up through the pump. If this check valve was not present, the non-pressure water storage tank could be damaged by the high pressure of the city water. Many check valves are integrated with the pump. Some pumps do not have a check valve, but a check

valve must be installed according to the RV standards. Most check valves are rated for 100 psi but will withstand 200 psi of backpressure.

6-2.1.4.3 Water Pump Installation

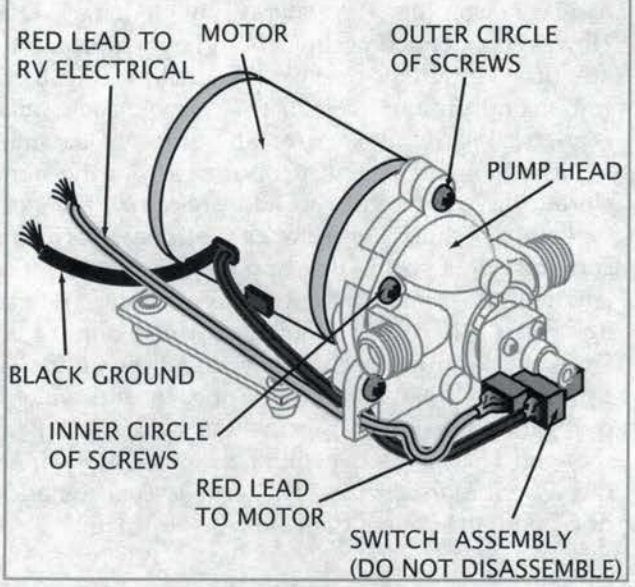
Location

Pumps can do their job regardless of how they are mounted. However, most pump manufacturers prefer the horizontal mounting position. If this is not possible, the best alternative is to mount the water pump with the motor on top. These positions help prevent any water from entering the motor portion of the pump in the unlikely event that a leak close to the motor should occur. Always check the appropriate service manual to determine the manufacturer's preferred installation procedures, location, and position. Water pumps work more efficiently when they are mounted near the water tank and at same level as the bottom of the tank. Most water pumps can be mounted above or below the freshwater tank. Water pumps can "push" better than they can "pull," but most are capable of self-priming if they are above the water level of the tank. Mounting the pump several feet or more away from the tank may cause a "starvation" of water supply while pumping, depending on the hose sizes and turns. Mounting a pump above the level of the bottom of the pump makes the pump first "pull" the water to it and then "push" the water to the fixtures. Making the pump do both pulling and pushing decreases the available pressure and volume. Generally, the higher the pump is above the tank, the lower the pressure and volume. In some cases, the pump could be too far from the tank and the system "starved." This could result in low water pressure and volume. If there is no starvation, this could be an indication of an air leak on the suction side of the pump. Always refer to the manufacturer's installation guide to make sure the location selected conforms to the pump's capabilities.

Water pumps normally create some noise when operating. Most pumps have rubber feet or similar apparatus to help control pump noise. Wood works as a good sound insulator. If possible, the water pump should be mounted to wooden structural members. A length of flexible hose between the pump and the water line system may also help curb noise. Be sure any hose used for this purpose is listed for potable water and has a pressure rating of at least 100 psi.

Mounting the water pump to a metal structure of the coach should be avoided. The rubber mounting feet should not be compressed too much, as this will reduce their ability to dampen sound. Tighten the mounting screws or bolts only enough to keep the pump from being loosened by road vibration. Some owners use pieces of carpeting or foam in the pump compartment area to reduce noise. If this is the case, make sure that there is sufficient clearance around the pump to avoid overheating problems.

Figure 6-83 Typical Water Pump Electrical Wiring



NOTE: Never wrap the pump itself. If wrapping is found, inform the owner of the safety hazard and request permission to remove the wrapping. Whether permission is given or not, notate the owner's notification and the action taken on the work order, sign and date it, and recommend to the owner that this is not a safe procedure.

Electrical Installation

Water pumps can draw from 3 to 10 A in a continuous operation and slightly more during startup and shutoff. It is critical to proper operation and owner safety that the water pump's wiring be sized and fused in accordance with manufacturer specifications. One manufacturer's installation instructions identifies acceptable wire sizes as 14 ga up to 20 ft (6 m), 12 ga from 20 to 50 ft (6 to 15.24 m), and 10 ga over 50 ft (15.25 m). This distance is a two-way distance. Up to 20 ft (6 m) means 10 ft (3 m) from the source to the pump and 10 ft (3 m) back to the source. Ideally, the pump should be on its

own circuit, with grounding to a common ground or the chassis. The vehicle's outer skin should never be used for grounding. Wiring must be done in accordance with the 4-1 of *ANSI/RVIA 12V Standard for Low Voltage Systems in Conversion and Recreational Vehicles* as described in *Chapter 6-5*. *Figure 6-83* shows the wiring of a typical water pump.

A proper 12 VDC source should always be available at the water pump. Extended operation with a low supply voltage can lead to motor burnout. Be sure the polarity of the power leads is correct when connecting or reconnecting the pump.

Inlet Plumbing

The size of piping required to connect the potable water supply to the inlet connection of the water distribution system is shown in *Table 6-3*.

Table 6-3 Minimum Size Tubing and Pipe for Water Distribution Systems

	Tubing		Pipe
Number of Fixtures	I.D. (in.)	O.D. (in.)	Pipe Size (in.)
1	1/4	3/8	3/8
2	1/4	3/8	3/8
3	3/8	1/2	1/2
4	3/8	1/2	1/2
5 or more	1/2	5/8	1/2

Piping size is dictated by the number of fixtures in the system and not by the length of the system. The sizing chart from *NFPA 1192* as shown in *Table 6-3* is based on the number of fixtures in a system. This is because the pressure available to a fixture is reduced as additional fixtures are used. Following the chart will help keep the available pressure more stable. Keep this in mind should a customer want more fixtures added. Changing the water lines to a larger size would be impractical, and the customer should be told of the effects of adding more fixtures. This would not be a safety consideration, but one of convenience.

Many RV water systems have five fixtures and would therefore require a 1/2 in I.D. (5/8 O.D.) tube or 1/2 in. pipe. The type of material that can be used is specified in *NFPA 1192* as described in *Chapter 6-5* or *CSA Z240*. Typical materials used for the water system include but are not limited to brass, galvanized wrought iron, galvanized steel, copper tubing (types K, L, or M, which refers to design specification thickness of the tubing and scribed on the tubing), listed plastic, or other listed or approved materials such as hose. The most commonly used materials are listed plastic, hose, and copper tubing.

The inlet to the water pump should be plumbed with listed hose. A short length of hose between the tube and the pump may be used to help reduce potential noise and vibration problems.

Water System Connections

Water system connections are usually sealed to prevent leaks. Pipe joint compound or thread lubricant needs to be identified as being acceptable for use with potable water. This means that the material will be nontoxic and insoluble in water. Teflon® tape is also appropriate for use with water systems, although it may not be stated on the label of the tape spool. Pipe joint compounds, Teflon® tape, and lubricants are to be applied only to male threads. If the material were applied to the female threads, the sealant, tape, or lubricant could get into the water system where it could eventually clog or otherwise foul valves or devices (refer to *NFPA 1192* as described in *Chapter 6-5* or *CSA Z240)*. Remember that no sealants of any kind are to be used on a flare fitting, compression fitting, or compression ring.

Barbed adapters can be used with an approved or listed potable water hose, but care must be taken to ensure that the hose remains kink-free during and after installation. If the hose has a kink or strain in it, it will probably cause a fitting to fail due to vibration and stress.

Water Strainer

Many water pumps come with a built-in strainer. The pump strainer is just a screened in-line washer used to protect the pump from possible debris. If the water pump does not have a built-in strainer, an in-line strainer can be used. Before adding a strainer, check to see if a strainer is attached at the water storage tank's outlet for the water pump, as they are sometimes installed here as well. Many owners desire a water filter that removes contaminants, such as chemicals or bacteria, from the water. These are available for installation in RV's and are typically installed where most people get their drinking water. These filters can be installed to serve the entire unit.

Outlet Plumbing

Anything that restricts water flow in the system can cause excessive water pump cycling.

It has been found in some situations that an elbow immediately downstream of the pump may cause turbulence that could restrict water flow. Removing the elbow and inserting a straight fitting and/or length of hose/piping of approximately 24 in. could alleviate the problem.

Faucet aerator screens should be checked regularly for potential clogging. The aerator screen is screwed onto the tip of the outlet of the faucet. It can be removed, cleaned, and put back onto the faucet end.

If there is a check valve at the water heater inlet, it must be installed in the correct position. If it is impossible to blow through the inlet readily, it could be installed improperly.

Checking Water Pump Operation

Before checking the operation of the water pump, take a few minutes to examine the installation. Make sure that the wiring is connected properly, that there are no kinks in the lines, and that there is water in the potable water storage tank.

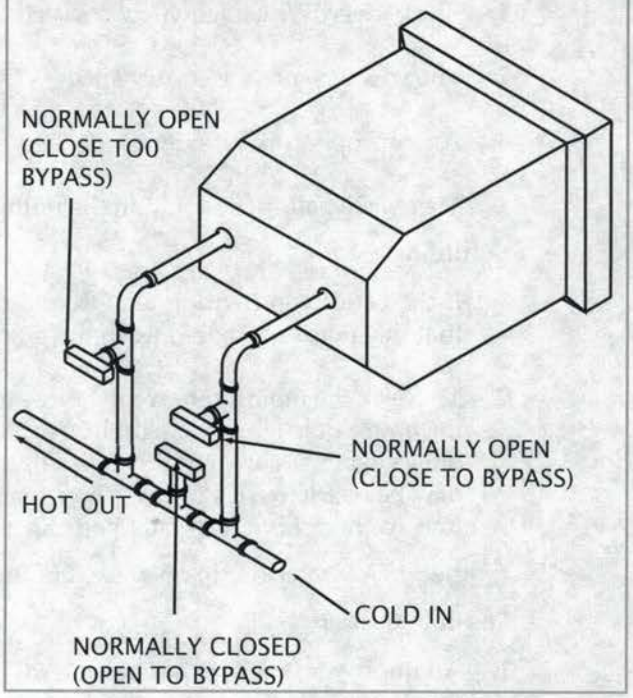
Be sure all faucets are turned off and turn the master pump switch on. The pump should run for a few seconds and then stop. Once the pump has stopped, this means that the water pump has pressurized the water lines of the system. Open the cold water faucet in the sink. The pump should start again, and water should flow immediately unless there is air in the lines. In this case, it will sputter very quickly after opening the faucet. At first there may be some sputtering as the air in the line is expelled. With the faucet at full flow, the pump may run continuously. With the faucet partially open, it may cycle (run-then-stop-then-run). Cycling with the faucet at partial flow is perfectly normal. If an accumulator tank is in the system, this accumulator tank will fill and assist in stabilizing the pressure throughout the system.

Once there is a steady flow of water, turn off the cold water faucet and turn on the hot. Make sure the water heater has water in it by opening the hot water faucet and observing whether there is a smooth flow of water. The water heater may have been drained previously when putting the RV into storage. The water pump will operate until the water heater is full. As with the cold water faucet, let the hot water faucet run until all the air is expelled and there is a steady flow of water. Any air in the water distribution system should be purged from every water line to every fixture. Once there is a steady water flow in both hot and cold lines at the sink, move to the lavatory sink, shower, and tub. Open the hot and cold water lines to be sure all in-line air has been expelled from the system. Don't forget the cold water line to the toilet. If all the air is not expelled, the pump will run longer before it shuts off, as it is compressing air.

When both the cold and hot faucet valves produce a steady flow of water at every fixture, and the pump turns off when the faucets are closed, the system is operating correctly.

Also be careful if the RV has "winterizing" bypass valves in the supply piping for the water heater. Ensure that these valves are open to allow water into the water heater. If the water heater has 120 VAC electric elements, and they are not immersed in water when the water heater is turned on, those elements can burn out in as little as 10 to 30 sec. When these elements are later immersed in water, they can become a ground fault problem for the electrical system.

Figure 6-84 Bypass Valve System for Winterization



Troubleshooting the Water Pump

The following troubleshooting procedures are general in nature and are not intended to be applicable to all water pumps, nor be all inclusive of problems that may be found. The specific guidelines provided in the correct service manual for the make and model water pump should be followed. The time taken when troubleshooting a water pump should be considered. The time it takes to find the problem, on top of the labor and parts, may quickly exceed the cost of installing a new pump.

A. **Problem:** Motor does not operate.

Possible Causes:

1. The battery is dead.
2. The wires are disconnected.
3. The battery terminals are corroded.
4. The system (master) pump switch is in the OFF position.
5. The switch is inoperative.
6. A fuse is blown.
7. The water pump microswitch is inoperative.
8. There are worn brushes or broken brush spring.

Solutions:

If the fuse is good and the wiring is the right size and properly connected, the problem is probably in the pump. To check the pump, complete the following procedure:

Test the input electrical wires to the pump with the coach water pump switch in the ON position. It should read about 12 VDC. If it is less than 12 VDC, check input voltage at the pump fuse. A drop in voltage from these two points indicate resistance or bad connection(s) between the fuse and pump connection. Also check for a good, clean ground. If there is proper voltage at the pump and it does not run, bypass the pressure switch by putting both red wires together. If the pump now runs, the pressure switch is defective and replacement is necessary. If the motor still does not run, the motor is defective. Depending on how old the pump is, a complete rebuild or replacement may be necessary.

B. **Problem:** Running the pump blows the fuse.

Possible Causes:

1. The battery is not adequately charged.
2. The wiring is not the correct size.
3. An improper fuse is being used.
4. There is a malfunction within the pump.

Solutions:

1. If the battery and wiring are OK and the correct fuse is being used, a blown fuse usually means that the motor or something in the pump assembly is frozen.
2. To check the motor, remove the three bolts from the inner circle (the innermost three) and remove the entire pump head assembly. Turn the motor on with the pump head assembly off. If the fuse blows again, a new motor is needed. If the motor runs without blowing fuses, the lower housing may be restricted. If the lower housing is restricted, the pump will not run. See the next section for how to check for a restricted housing.

C. **Problem:** The water pump operates, but the motor is extremely hot.

Possible Causes:

1. An improper wire size has been used.
2. The battery is not adequately charged.
3. Faulty brushes or faulty motor brushings are causing a motor malfunction.
4. The lower housing is restricted.

Solutions:

1. If the wire size is OK and the battery is adequately charged, check the motor in the following manner:
2. Remove the three screws in the inner circle as above. Remove the pump head assembly from the motor. Run it for at least three minutes. If the motor gets hot, replace it. If the motor runs OK, the lower housing may be frozen. To check for a restricted lower housing, stick a screwdriver in the motor shaft hole (choose one that won't quite go through) and see if the lower housing can be turned. If the lower housing does not rotate, replace it with a new one. If the lower housing rotates freely, check for loose screws.

D. **Problem:** The water pump runs, but water flow is slow, intermittent, or nonexistent.

Possible Causes:

1. The water tank is almost empty.
2. Air is leaking into the inlet hose fittings.
3. The built-in water pump screen or strainer is plugged.
4. There are kinks in the lines of the system.
5. The inlet line to the water pump is plugged.

6. The in-line water strainer is plugged.

7. A motor bearing is worn out.

8. There is a bad diaphragm.

9. The faucet screen(s) may be plugged.

10. It could be low voltage causing the pump to run slowly.

Check each of the above items carefully. If they are correct, verify that all exposed screws are tight. If the screws are tight, the problem is probably inside the water pump, which will require the pump to be disassembled. To disassemble the pump, follow the manufacturer's recommended procedures. The following shows an example of such a procedure from a specific pump manufacturer:

1. Remove the pump head assembly from the motor. The pump head assembly and the motor should separate easily. Ensure that the six inside screws are secure and tight. If they need tightening, do so and reassemble the unit and test. If the screws were tight or a test does not work, the next step is to check for foreign material in the pumping chambers.

2. Separate the upper and lower housings. Remove the three-leaf clover-shaped valve assembly that either rests on the lower housing or is in the upper housing.

3. Inspect the inlet and outlet ports that are exposed when the valve assembly is removed. Remove any foreign material that may have lodged there.

4. Inspect the valve assembly and remove any foreign material. Check for swollen inlet valves. If no foreign material is found, the likelihood is that the three valves in the pump's three pumping chambers are swollen or distorted (bleach can cause this). A normal inlet valve fits flat and snug in its pumping chamber. A swollen valve is usually puckered and spongy to the touch. Replace the valve as necessary.

5. Reassemble the water pump. To reassemble the water pump, place the valve assembly carefully over the three pistons as directed in the service manual. Carefully rejoin the upper and lower housings with the three short screws. Make sure the housing assemblies fit together properly.

E. **Problem:** Sputtering when a faucet is turned on.

Possible Causes:

1. The water tank is almost empty.

2. Air is leaking into the water pump.

Solutions:

1. If the water sputters when a faucet is turned on, it usually means either that the tank is nearly empty or one of the inlet connections has loosened. Make sure the water tank is full.

2. Tighten all screws and connections on or near the pump.

F. **Problem:** The pump runs (cycles) when the faucets are off.

Possible Causes:

1. There is a leak in the plumbing lines.

2. A toilet is "running."

3. There are leaking fixtures.
4. A leak exists in the water pump.
5. The city water check valve is leaking.

Solutions:

1. Check for a leak somewhere in the plumbing or in the pump itself.
2. Check for loose inlet or outlet connections.
3. Check the entire plumbing piping system, paying special attention to all connections and fittings. Repair any leaks found.
4. Check all faucets for leaks. Tighten connections or replace washers as necessary.
5. Check the toilet. Repair/replace toilet components as necessary.
6. Check the water pump for leaks. Check all screws for tightness. Disassemble the pump and look for holes in the pump's diaphragm. Check that pistons are assembled properly and the seal is tight.
7. All leaks in the system that involve the fittings, piping, and fixtures will be evident by water in the area. The city water check valve will have water coming from the outside. A leaking water valve in the toilet will be evident by the toilet bowl filling to the overflow or by water leaking from the valve itself. If the seal in the toilet bowl does not seal, water in the bowl from the upper rim to the drain will be evident. Another cause of a pump cycling is the internal check valve in the water pump itself. If the check valve does not hold the system pressure and lets the water leak back into the water tank, thus dropping the pressure, the pump will cycle on and repressurize the system until the valve is repaired or replaced.

G. **Problem:** The pump goes on and off when the faucets are on.

Possible Causes:

1. The water lines are restricted.
2. The pump outlet is restricted.
3. There is a faulty pressure switch.
4. The faucets are only partially open.

Solutions:

1. Remove the water line restrictions such as kinks or debris.
2. Clean the pump outlet of any debris.
3. Replace the faulty pressure switch.
4. Replace the defective faucet valve.
5. Replace or clean the faucet aerator.

H. **Problem:** The water pump runs roughly and/or is noisy.

Possible Causes:

1. There are loose hangers or anchors.
2. The water pump is leaking.
3. The pump was installed improperly.

Solutions:

1. Check all hangers and anchors to ensure that they are tight and snug. Make sure what is being heard is not unwanted vibration but is a water pump-related noise.
2. Check all screws for tightness. Tighten screws that are loose. Remove the pump head from the motor using the innermost ring of screws. Operate the motor separated from the rest of the pump. If the motor runs roughly, it is malfunctioning and must be replaced. If the motor runs smoothly, the problem is likely in the pump head. Make sure all screws in the pump head are tight. If they are loose, tighten them, reassemble the pump, and try again.

I. **Problem:** The pump won't shut off.

Possible Causes:

1. The water pump master switch is wired improperly or is being bypassed.
2. There is a hole in the pressure switch diaphragm.
3. There are loose screws in the lower housing.
4. The microswitch in the pump itself is faulty.
5. The water pump valves are swollen or worn.
6. There is air in the water system (the pump will run and compress the air).
7. There is a major leak or empty tank.

Solutions:

1. Check all wiring to ensure proper installation.
2. Check the entire piping system for water leaks. Especially check for loose screws, and tighten as necessary (the procedure is described above).
3. Separate the pump head assembly from the motor and check the motor microswitch. Check the valves as described above. Replace as necessary.

J. **Problem:** The RV's lights dim significantly when the pump comes on.

Possible Causes:

1. The battery is at a low rate of charge.
2. The wiring size is too small.
3. The lower housing is frozen.
4. The motor is open or shorted.

5. There is a converter malfunction.

6. The pump may be on the same circuit as the dimming lights.

7. There is a faulty ground connection.

Solutions:

1. Check the battery output. If the battery is not adequately charged, recharge or replace the battery.

2. Check all wiring. If the wiring size does not meet the size requirements of the service manual, rewire the system to the correct requirements. See *Table 6-4* for an example of a manufacturer's general wiring size guidelines. After installation, check the voltage at the pump motor. The voltage should be checked when the pump is operating at the same time as all the inside electrical fixtures. Full voltage must be available at the pump motor at all times. Use a multimeter and check the voltage. The reading should be consistent with the voltage indicated on the data plate of the pump.

3. Check the motor operation. Remove the three screws in the inner circle, and remove the pump head assembly from the motor. Run the motor. If the lights dim, replace the motor.

4. If the motor runs OK, the lower housing may be restricted. To check for a frozen lower housing, stick a screwdriver in the motor shaft hole (choose one that won't quite go through), and see if the lower housing can be turned. If the lower housing does not rotate easily, replace it with a new one. If the lower housing rotates freely, check for loose screws.

It should be noted that most pump manufacturers recommend that the pump be wired on a circuit of its own. If the pump is on a circuit with other loads, it should be another intermittent-duty motor device, such as a furnace or exhaust fan. The lights will still dim if the voltage in the battery is low, but with a fully charged battery, the lights should not dim significantly. If the pump is on a circuit with another load, whenever the load is applied, the voltage will drop. How much depends on the load applied, and the pump motor will slow accordingly.

Table 6-4 General Wiring Guidelines Example (Sample Pump Circuit)

Total Length	0–20 ft (0–6m)	20–35 ft (6–11m)	35–55 ft (11–17m)
12 VDC 10 A load	#14 AWG 0.0641 in. (2.08 mm^2)	#12 AWG 0.0808 in. (3.31 mm^2)	#10AWG 0.1019 in. (5.26 mm^2)

NOTE: AWG expressed in inches denotes the diameter of the wire. AWG expressed in square millimeters (mm^2) denotes the area of the wire.

Manual Hand Pumps

Manual pumps are hand operated and relatively inexpensive. Some parts are not available for them, but parts such as O-rings can be substituted if they are the same size as the originals. Problems with the pumps can be analyzed relatively easily. The most common problem is lack of use coupled with the fact that the water will dry out, leaving a calcium deposit on the O-ring and pumping chamber. Disassembling the pump, cleaning out the calcium deposit ring, and replacing the O-ring will usually repair the pump. Care must be taken to seal the pumping chamber so no air will enter during the pumping stroke. Usually, these pumps have a small ball at the inlet that acts as a check valve, and it will hold the water in the chamber in addition to the line to the

pump from the tank. If the ball gets calcium buildup on it, the pump will not be able to hold the water up to the pump, and excessive pumping will occur each time the pump is used. These pumps normally will lose their prime in a day or so but should hold it if they are used every day. The pump should prime itself when it works normally, but it will take a few strokes to prime it after it has not been used for a while. If it is completely dried out and there are calcium deposits, the O-ring cannot seal on the strokes. In this case, air will enter when the O-ring passes over the deposit, thus defeating the pumping action, or bringing water up to the pump. There are also O-rings on the pump handle shaft that must be inspected for wear and buildups. After removing the deposits, silicone lubricant can be used to lubricate the O-rings. If wear and buildups are excessive and cannot be removed or repaired, the pump can be replaced.

Non-demand Electric Pump

Non-demand water systems utilize a small electric water pump, a switch, and a faucet. The switch may be incorporated in the faucet, or it may be located on a cabinet close by the sink, as it needs to be pushed when water is desired at the faucet. The faucet does not have a valve on it. Sometimes a hand pump can be used as a faucet that provides a backup system if the electric pump fails. Typically, the pump will be the part that fails. These pumps are usually of the impeller design, which means that an impeller rotates on the end of a motor, and the impeller is off center in the pump chamber. Water is introduced into this chamber and is brought around the pump to an outlet as the size of the space between the impeller decreases. The main problem concerning these pumps is that they require close tolerances for the impeller to function. When the water evaporates, it leaves behind a calcium deposit that will cause the pump to stick. The motor is not powerful enough to overcome this, and it either blows a fuse or burns up. Any debris that might enter the pump will also jam the impeller and cause failure.

These pumps are non-rebuildable, so they must be replaced. This type of pump usually is not capable of priming itself, so it must be mounted at the bottom level of the water tank so it will be fed by water pressure from the tank (gravity) before it pushes the water up to the faucet. Some pumps have pipe threads and/or barbs on their in and out fittings. These can be screwed into the tank directly or plumbed by piping.

Air Compressor Systems

Loss of water pressure in an air compressor system is commonly a result of depleted air pressure in the system. Check the pressure gauge and repressurize the system with compressed air if necessary. Depleted air pressure can be due to water flow or a leak in the air system. If an air leak is suspected, a leak detection solution (e.g., a child's bubble blowing solution) may be used. Simply pressurize the system, making sure the storage tank is at least half full of water, and test all fittings with the bubble solution. If a leak is present, bubbles will appear at the leak. Repair any leaks found and retest until the system holds a steady pressure. Fittings include the fill assembly, fill cap, air pressure inlet, air line from the tank to the air compressor, and any other fittings above the water line. If the system loses pressure due to water flowing from the tank, either the faucets are being used, or water will be evident wherever it is leaking from in the system.

The air compressor itself can be defective. The compressor is a component of the piston and needs assembly design. They are relatively trouble free, but they can fail. The manufacturer would have to be consulted about the parts available before repairing it. Some compressors are obsolete. If the compressor runs but does not pressurize the tank or system, either the compressor is defective or there is a system leak. Check to see if the system holds pressure by disconnecting the compressor, sealing the line to the tank, and pressurizing the system. If it does, the problem is probably in the compressor. Removing the faulty compressor and replacing it with a new one might be a requirement, depending on its age and part availability. Repair costs are also very expensive, so it may be best to install a demand pump.

6-2.1.5 City Water Service Connection and Backflow Prevention

A check valve, or backflow preventer, must be located at any city water service connection if the water distribution system has a non-pressurized water tank and is connected to city water. The check valve is needed to protect the city water system from contamination by backflow of water from the RV's water system. It also

prevents water from running out when the city water inlet is disconnected. Check valves are required to be either integral with, or immediately adjacent to, any city water service connection outside the RV.

The check valves of city water service connections should never be disabled. Visually check for the presence of a check valve at the city water service connection. Look into the 3/4 in. female swivel connection on the outside of the RV. Inside this fitting, a spring and T-bar assembly should be visible. A defective check valve will be evident by water leaking when the RV water pump has pressurized the water system. Replace any defective check valve by replacing the city water service connection assembly and check valve if separate. Three-quarter-inch female swivel fittings for hose attachments without the spring and T-bar are not equipped with a check valve. These types of fittings are often used for waste holding tank flushing systems. These connections typically do not have a check valve at the hose connection but have the check valve located farther downstream within the system.

Replace defective city water service connections by removing the screws holding the device to the RV exterior. Pull the device forward to access the connection of the tubing to the city water service connection. Check for access behind the service connection. It may be easier to work from the inside than from the outside. In most cases, the connection will be a 1/2 in. female pipe thread fitting. Usually, enough tubing will be available for the tubing to be cut to remove the defective fitting, and a new city water service connection can be installed. If there is not a sufficient length of tubing to allow a new city water service connection to be added, the water line will need to be extended. Cut the tubing back so an additional workable length of new tubing can be added.

If a city water service connection or a check valve needs to be replaced, it may be due to mineral deposit buildup from the water. RVs see many water sources over the course of their lifetime, and some of the water is very "hard" (high mineral levels in the water). When checking the fittings or devices in the system, look for mineral deposit buildup, which is usually whitish-yellow and very hard. It may help explain to the customer the reason for the failures. When installing a new connection, be sure to clean off old putty tape or sealant from the coach sidewall, apply new sealant material (putty or butyl tape) to the city water fill assembly, and reattach it to the RV. Trim excess sealant from the edges of the fill assembly edges.

Configurations that allow filling of the water storage tank from the pressure water piping system within the RV are allowed, providing the tank vent is unrestricted and larger than the pressure fill pipe. Otherwise, the tank is subject to pressure, and this voids its listing. Fittings used for this type of installation are also to be considered in determining if restrictions exist. Again, the tank vent through its entire run must be larger than the pressure fill line.

6-2.1.6 System Low Point Drains

The water distribution system must have provisions to allow the entire freshwater system to be completely drained by gravity. This is a requirement in *NFPA 1192* as described in *Chapter 6-5* and *CSA Z240*. This will usually consist of drain outlets in both hot and cold water supply lines, located at the lowest point in the water distribution piping. Another possible low point drain may be the petcock of the water heater. Several low point drain openings may be required to meet the intent of the standard. Low point drains will rarely require repair.

6-2.2 Drainage Systems

As explained in *Chapter 6-1*, the RV's drainage system consists of a piping system to convey wastewater from the sinks, shower, and other locations to the holding tanks and/or main drain termination(s). The drainage system in RVs is almost always constructed with black ABS piping. Some venting, especially where it is visible after installation, may be white ABS. Be sure ABS and PVC materials are not intermixed. If ABS and PVC need to be intermixed, cement that is compatible for both materials must be used. This will be clear from reading the label on the cement container. Solvents actually melt the plastic and "weld" the materials together. For this welding to take place, the material and the solvent must be compatible. If joining PVC and ABS, solvent will not work. An appropriate cement must be used!

The drainage system will have traps and vents, the purpose of which was explained in *Chapter 6-1*. Basically, installations and repairs of the drainage system involve techniques for joining ABS pipe, a very simple procedure.

6-2.2.1 Health Information

Working on the sanitation disposal portion of the wastewater system is probably the least desirable task for an RV service technician. It may be undesirable, but it is not dangerous. The Centers for Disease Control (CDC) in Atlanta, Georgia, has stated that contracting the HIV AIDS virus from working with wastewater is not possible. According to CDC, the virus cannot survive outside the human body, and the environment found in a sanitation system is not suitable for its survival. However, there are other minimal health risks associated with contact with human waste and the microorganisms that it may contain. Care should be exercised whenever servicing used sanitation fixtures and tanks. To minimize personal contact, protective gloves should be worn. These gloves should be a barrier type made of polyethylene, latex, or bunal rubber. Wash the gloves with warm water and soap or dispose of the gloves after use. RV service technicians must follow good personal hygiene practices of washing hands thoroughly before eating, drinking, or smoking. All tools used in the service operation should be cleaned and decontaminated. A spray disinfectant such as Lysol is adequate. Exposure to wastewater is minimized by draining the tanks and flushing them several times.

6-2.2.2 Piping

The drainage piping system is designed by the RV manufacturer to comply with *NFPA 1192* or *CSA Z240* (refer to for size and types). The standard stipulates many requirements for the design of the drainage system. Since the technician will be repairing systems much more frequently than installing complete new systems, complete knowledge of all specific plumbing design standards may not be necessary. As a general rule, any repairs made to the drainage plumbing system should maintain the original design of the system. Piping sizes should not be altered, and traps and vents should be replaced with similar components as necessary. ABS pipe sizes common in RV drainage systems are 1-1/4, 1-1/2, 2, and 3 in. Three-inch pipe is used in the main drainage system of toilets and black water waste holding tanks. Gray water holding tanks can use a minimum drain line size of 1-1/2 in.

ABS piping installations and repairs are easily performed, since ABS pipe is easy to cut and join. The procedure is as follows:

1. Cut ABS pipe with a miter saw, circular saw, hand saw, hacksaw, or other tool. Ensure that the cut is square to the pipe.
2. Remove burrs or chaff from the inside and outside of the cut surface.
3. Apply listed ABS cement generously around the entire outside edge of the pipe to be joined.
4. Apply listed ABS cement generously to the inside of the fitting shoulder.
5. Insert the pipe into the fitting and twist the pipe one-fourth turn and then back one-fourth turn within the fitting, ensuring that the pipe is inserted all the way up to the fitting's shoulder. This also helps to ensure that the fitting is properly aligned for the installation.

Both ABS and PVC (including CPVC) should have specific lengths and fittings determined during the actual assembly within the RV. Some planning of the piping and fittings to be used is helpful, but for the most part, preassembly of the pipe helps with proper alignment and fit. Using a petroleum-based lubricant to preassemble the pipe would require some type of solvent to completely remove the lubricant. Any residue left behind, even a single spot, could cause a leak and/or damage the pipe. It is sometimes impossible to assemble a drain system in place. Usually, the pipe fittings can be assembled dry, then each fitting marked in relation to the pipe, before they are disassembled. When they are reassembled with solvent or cement, they can then be positioned in the proper orientation with each other. Sometimes a portion of the drain line can be completely assembled with solvent or cement on the bench, and the "subassemblies" assembled in the coach.

Most drainage piping system installations and repairs involve this simple procedure. Problems in the ABS drainage systems fall into the following categories:

Leaks. A procedure for testing the system for leaks will be outlined later in this chapter. Leaks located at P-traps can often be repaired by tightening the threaded hub connection. If this fails to eliminate the leak, simply replace the trap. Leaks at other places in the system are repaired by cutting out the leaking fitting or piping and reconnecting the piping with new fittings and pipe as necessary.

Clogs. Clogs or blockages within the drainage system will stop the flow completely or severely limit it. Clogs at P-traps are cleared by removing the P-trap, clearing the trap, and then reinstalling it. Blockages at other points in the system should be cleared using a clean-out tool. Points of access for clean-out tools include P-traps, roof vents, clean-out access fittings, and some anti-siphon trap vent devices (ASTVDs or "vent-checks").

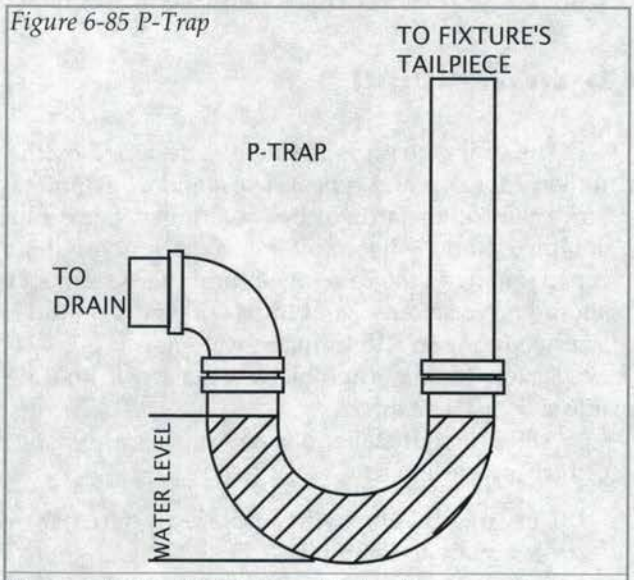
Slow Flow. Chronic slow flow is not always related to blockages. Slow flow can be the result of insufficient venting within the system. Lack of airflow in the system can create drainage problems. As water flows through the system, the water will push the air in the lines out of the system. In addition, air will follow the water into the system. Lack of airflow provided by the vent system can retard water flow or stop it altogether. Ensure that the roof vents are clear of blockages and ASTVDs are functional. In extreme cases, additional ASTVDs can be installed or the size of piping or venting increased in the problem section of drainage piping.

6-2.2.2.1 Traps

P-traps

P-traps will be located at the drain outlet of every fixture. They connect to the fixture through a pair of threaded connections. One set of threads is on the P-trap itself; the other set is at the fixture. In small sinks and lavatories, the fixture tailpiece is attached to the fixture, and the P-trap has a slip fitting that tightens around the tailpiece for a tight connection. In other applications, the P-trap may be glued to a fitting, and the fixture's strainer has to be unscrewed to remove the P-trap. A visual inspection of the fixture attachment method will allow provide information used to determine the means of disconnection. Most P-traps are easily removable for repair, cleaning, or replacement.

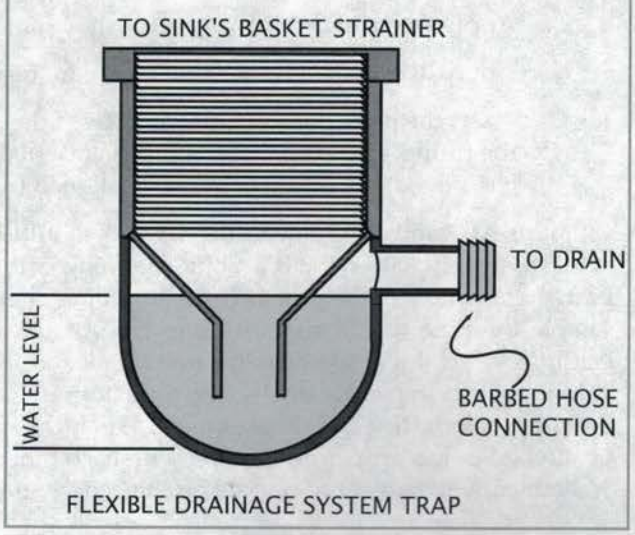
Figure 6-85 P-Trap



Flexible Drain Systems

Many smaller RVs may contain only a single fixture. In these RVs, it is common to find the use of a flexible drain system. This flexible drain system is a listed assembly consisting of a plastic bell trap connecting to the sink outlet, a length of flexible hose, and an outlet fitting that typically is attached to an exterior wall. However, the outlet fitting may be installed to exit through the RV floor. The hose is connected by hose clamps to both the bell trap and the outlet fitting. These systems are usually trouble free and seldom require repair or service.

Figure 6-86 Flexible Drainage System Trap

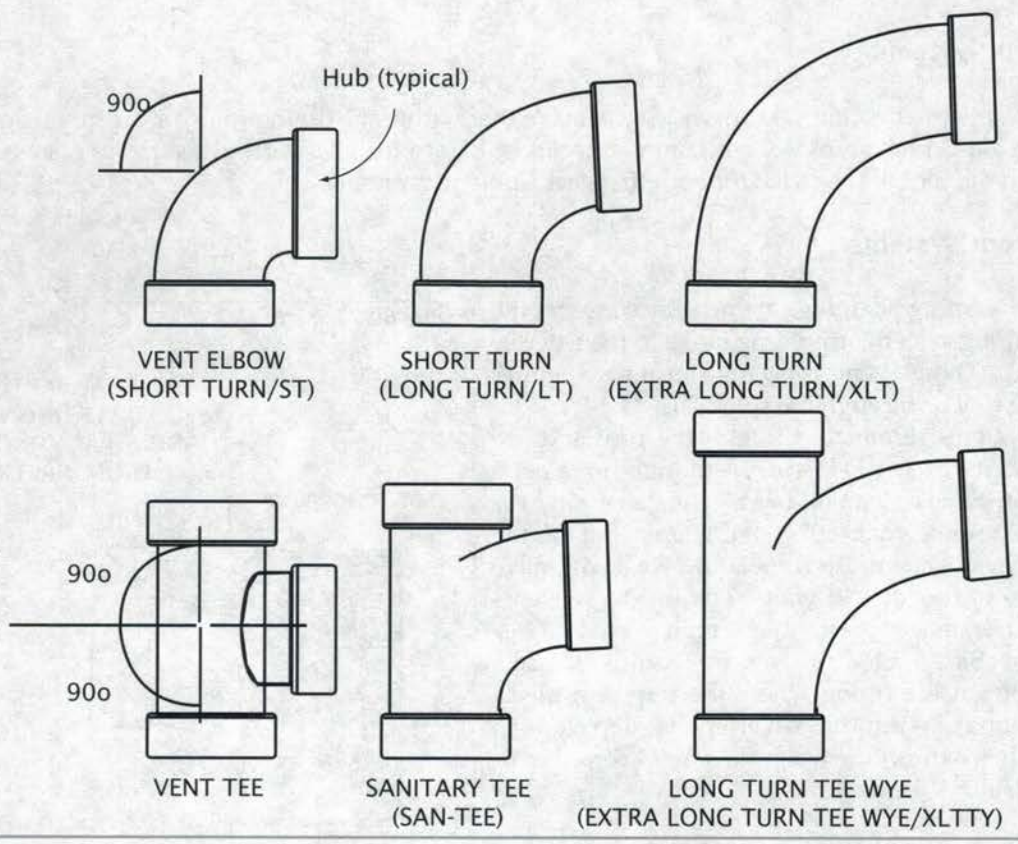


6-2.2.2.2 Slope

Drainage piping within the drainage system must be installed with a slope toward the holding tanks or main drains to ensure flow. The minimum allowable amount of slope is 1/8 in. (3.175 mm) per foot (30.48 cm). While slope is important to ensure good drainage, too much slope can lead to other problems. If the slope of a trap arm is too great [more than 1/4 in. (6.3 mm) per foot (30.48 cm)] the draining water could generate enough speed to suck more water out of the P-trap than intended, causing the water seal within the trap to break. This could lead to the introduction of sewer gas into the RV. Remember that sewer gas cannot penetrate water, and the P-trap is installed so there is always water in the trap to keep sewer gas out of the RV.

To help ensure that appropriate slope is maintained in a drainage system, listed drainage fittings are designed with a "built-in" slope of 1/4 in. (6.35 mm) per foot (30.48 cm). It would be impossible to build a piping square of ABS pipe using 90° drainage fittings unless the fittings are specifically designed and listed as "vent fittings." Always be sure repaired areas of the drain piping system maintain this slope. Vent systems are not required to have slope, since they pass only air, not water. Therefore, vent elbows have true 90° turns. Vent elbows or "ells" can be identified by nearly touching hubs. *Figure 6-87* shows examples of typical drainage fittings.

Figure 6-87 DWV Fittings



6-2.2.2.3 Support

Drainage piping must be secured at a minimum of every 4 ft (121.9 cm). The piping may be strapped, hung, or tied down to any solid structure within the RV. Repaired or installed drainage lines should be secured to ensure that proper slope is maintained.

6-2.2.2.4 Venting

The importance of proper venting cannot be overstated, especially as it relates to odor control. In addition, without correct venting, sinks will not drain properly, bacteria can spread, and holding tanks will not drain as quickly or completely. As a holding tank empties or a sink drains, fresh air must enter the drainage system. Since RV fixtures and holding rely solely on gravity to empty, having air enter the system as sinks and tanks are drained results in a faster and more thorough process. Two types of vents are used in RV waste systems: direct exterior vents and the aforementioned anti-siphon trap vent devices (ASTVDs).

Venting in the drainage systems allows the flow of air into and out of the system. Airflow is needed to ensure the flow of water. To demonstrate the need for air to create liquid flow, try this experiment with a straw and a glass of water. Place the straw in the water and remove the straw. Notice the liquid runs out of the straw as it is removed. Return the straw to the liquid and this time place a finger over the exposed end of the straw. Hold this position as the straw is removed from the water. Notice that the water remains in the straw. Hold the straw over the glass and remove the finger. Notice that the introduction of airflow allows the liquid to run out. This is venting.

This same principle applies to the drainage system in the RV, and venting ensures adequate airflow for the system to function. Vents in RVs are of two types: exterior venting or the anti-siphon trap vent device (ASTVD).

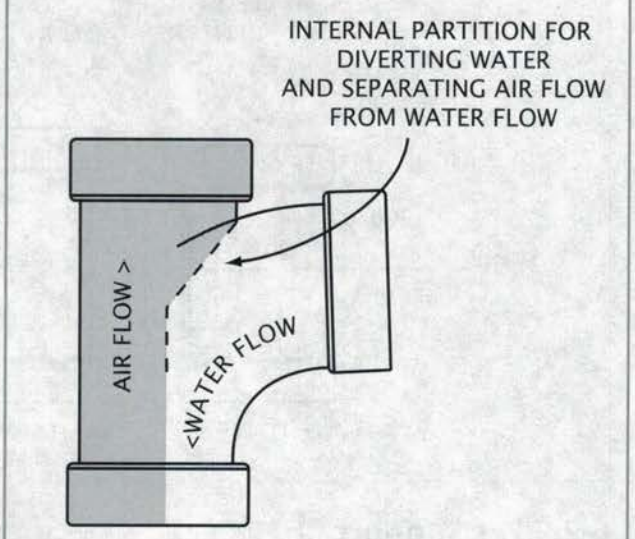
Direct Vent Systems

Direct vent systems connect the waste systems (either within the drain piping or directly from the holding tank) to the atmosphere outside. It is common for most RVs to install a vertical section of plastic ABS pipe up and through the roof of the coach for both the black and gray systems.

Exterior Vent Systems

Exterior venting is piping that directly connects the drainage piping system or holding tanks to the exterior atmosphere. These vent systems terminate either through the roof or through the sidewall. Most RV exterior vent systems terminate through the roof and are typically referred to as *roof vents*. Although not a code requirement, some coach builders also install a cap over the roof vent pipe to keep contaminants out of the plumbing waste system. An RV's liquid waste drainage systems can have sidewall vents. These exterior vents are part of a drainage system that is referred to as a *side vented system*. Side vented systems are required to use a "diverter tee" at the fitting where the trap arm meets the drain and vent. The diverter as depicted in *Figure 6-88* helps direct the water flow and keeps the fitting open to allow the flow of air.

Figure 6-88 Diverter Tee



Anti-siphon Trap Vent Device (ASTVD)

The anti-siphon trap vent device (ASTVD) or "check vent" depicted in *Figure 6-89* is a secondary vent that can only be used in applications where an exterior vent is also provided. As already stated, the venting system allows air into and out of the drainage system. The ASTVD uses an atmospheric pressure-controlled valve that will allow air into, but not out of, the system. Because it does not allow air out, it must be used in conjunction with a primary vent, i.e., exterior vent.

The seal of the ASTVD needs to be positioned so it is at least 6 in. (152.4 mm) above the fixture's trap arm. The ASTVD screws into an adapter fitting that is a permanent part of the drainage system. When installing or replacing an ASTVD, be sure it is only hand tightened. Overtightening may crack the adapter fitting. ASTVDs that allow gases to escape into the RV should be replaced.

Figure 6-89 Anti-siphon Trap Vent Device

6-2.2.2.5 Cements and Solvents

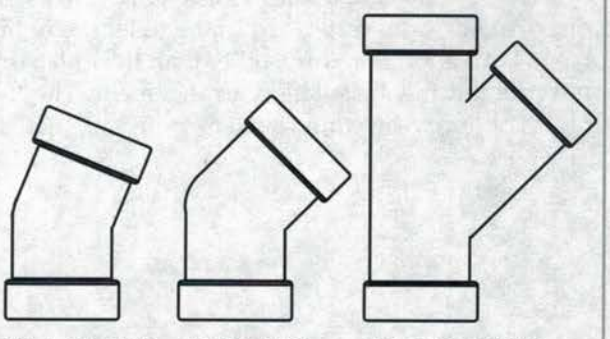
Connections of pipe and fittings in the drainage system are made by solvents or cements. The solvent used for connecting ABS materials is often referred to as *solvent weld*. This is because the solvent actually welds the plastic parts by chemically melting them together. Solvents will "set up" quickly, especially in a warm weather. Typically, only about 30 sec is available to put the fittings together, rotate them, and adjust them to their proper orientation. Use only listed ABS solvent for joining ABS pipe.

With other types of plastic drainage pipe, use a solvent or cement specifically labeled for the materials being connected. The solvent or cement either bonds or welds the parts together. Use only listed PVC cement, primer, and cleaner for joining PVC pipe. With other plastic, such as CPVC, be sure to read the label to ensure that the cement or solvent is listed for use with the materials to be connected. In some cases, it may be necessary to connect ABS and PVC pipe and fittings together. Use listed ABS/PVC transition cement for joining ABS and PVC pipe. This type of cement is not very common. Unless the label on the container states the cement is suitable for connecting ABS and PVC, do not use it, because it will not hold.

The procedure for using PVC cement is the same as ABS cement outlined above. Always be sure to check the installation instructions for each specific product.

6-2.2.2.6 Fittings

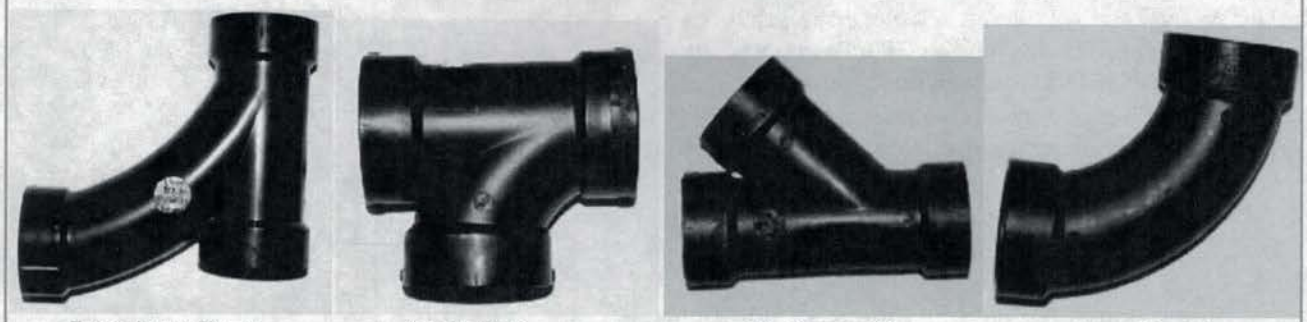
Figure 6-90 Angled DWV Fittings



Directional changes in the drainage system are made with fittings having angles of 11-1/4°, 22-1/2°, 45°, 60°, or 90°. The most common are 45° and 90° fittings. Fittings are designed to one of three different radii or sweeps. Some examples are shown in *Figure 6-90*.

When using individual or combination fittings, the sweep of the fitting is important to ensure adequate water flow. Fittings called Ts and Ys are used to add branch lines and change direction or elevations. These fittings have sweeps that are equivalent to 90° bend fittings or elbows. When replacing fittings, use identical fittings in the repair of a section of drainage piping unless it is obvious that an error was made. In that case, change to the correct fitting for the application. Consult *NFPA 1192* or *CSA Z240* for specific requirements regarding fitting types when constructing a new system.

Figure 6-91 Fittings



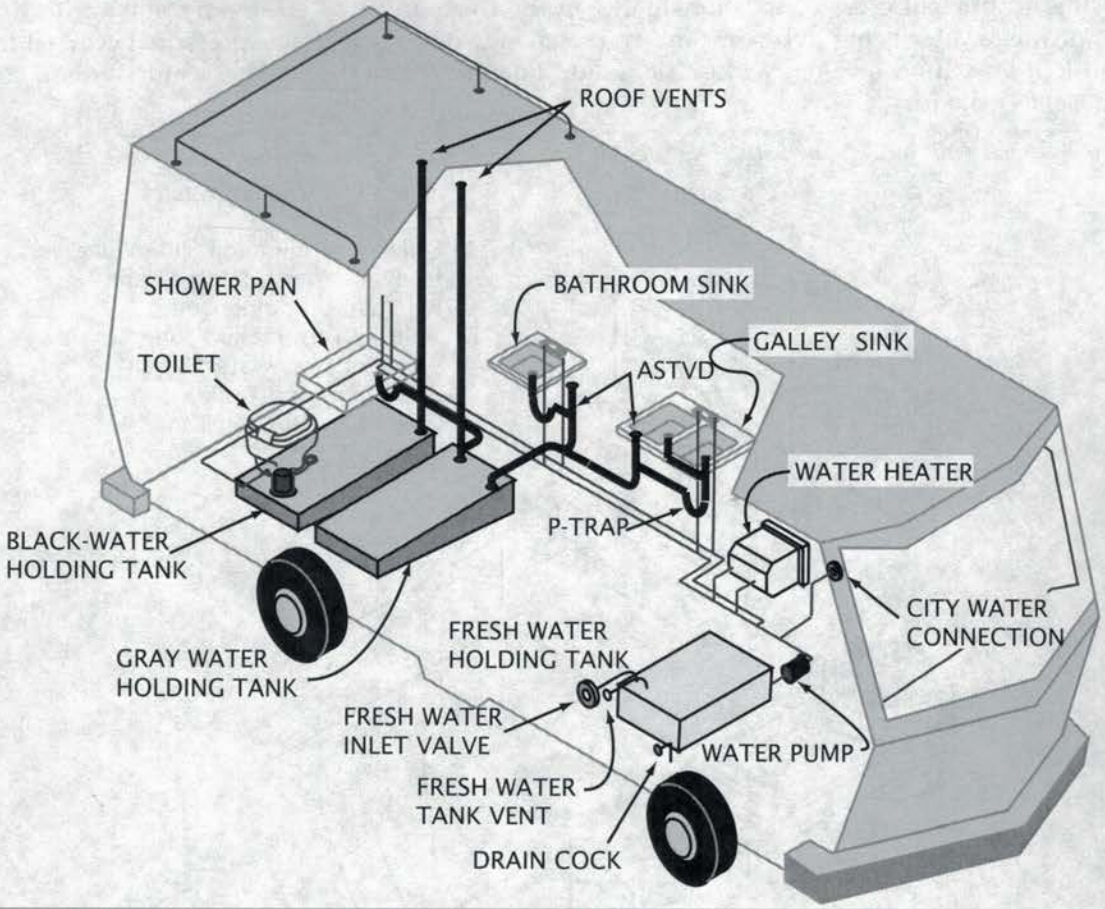
6-2.2.3 Wastewater Holding Tanks

Wastewater holding tanks are used to collect the wastewater of the RV and safely store it on board until it can be emptied into an in-ground sewer system. There are no rules dictating the number of holding tanks required on an RV or stipulating even that they need to be provided, except when there is a mechanical seal toilet installed. Small RVs, such as truck campers, may have a holding tank for the toilet, but the sink and shower may bypass the holding tank with piping connected directly to the main drain. Depending on the floor plan and configuration of the RV and its structure, some RVs may have only one holding tank, others two, and some actually have three. RVs manufactured today typically have two waste holding tanks as depicted in *Figure 6-92*.

Each holding tank outlet has a fullway termination valve installed prior to the drain outlet. The fullway termination valve has several names: gate valve, slide valve, knife valve, blade valve, or dump valve. These valves, when open, create an opening with a cross-sectional area equal to the diameter of the drain line in which they are installed. The drain may be a single drain from each holding tank, or the drains may be interconnected with a single outlet serving all holding tanks. In every case, the drains from holding tanks are within 22.5 ft (6.85 m) of the rear of the RV. This location requirement is from *NFPA 1192* or *CSA Z240* and was established so that only a single length of 10-ft sewer hose is needed to be attached by the consumer for holding tank dumping.

When two wastewater holding tanks are used, the RV manufacturer normally separates the liquid waste, often called "gray water," from the toilet (body or solid) waste, called "black water." However, it is permissible to have another fixture, other than the toilet, drain into the black water holding tank. The RV standard does not prohibit this installation arrangement. The third holding tank is often a gray water tank and is used for high-volume wastewater, such as from a clothes washer.

Figure 6-92 RV Wastewater System



6-2.2.3.1 Black Water Holding Tank

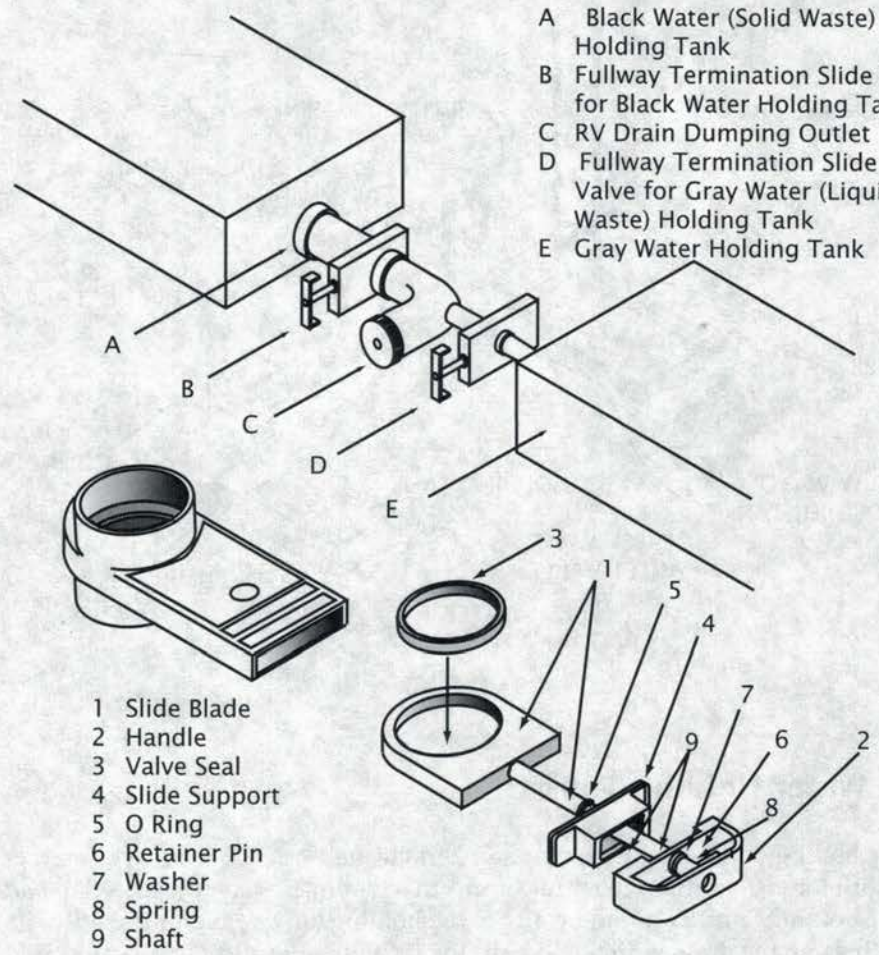
The black water holding tank should be emptied and cleaned prior to service or storage. Holding tanks should be over half full for proper dumping. This means that, at times, water may need to added to the tank to effectively dump the holding tank. By adding water to the holding tank, remaining solids will be broken down further and carried through the drain with the force of the weight of the additional water. *Figure 6-90* identifies the components of the drains and fullway termination valves (B and D) used for dumping. Remember to always dump the black water holding tank (A) first. This allows the gray water tank (E) to "rinse" the hose later. To dump the black water holding tank, connect the 3 in. flexible drain hose to the dumping outlet (C). The RV drain outlet will be equipped with a manual disconnecting hose coupling device for clean and easy attachment of the flexible dump hose. Attach the other end to the dumping station or campsite hookup, if permitted. Make sure that the gray water fullway termination valve is closed before dumping. This will prevent the black water waste from backing up into the gray water holding tank while the black water is being drained. Pull out the termination valve handle fully and let the holding tank drain.

After dumping the black water holding tank, the tank should be cleaned to remove as much waste as possible and help sanitize the tank further for either storage or additional usage. To clean the holding tank, the fullway termination valve or slide valve should be closed and the tank filled with potable water to at least one-fourth to one-half full and drained again. When it is empty, close the valve again and add several U.S. gallons of water. Add an appropriate amount of approved holding tank deodorant/cleaner (available at all RV stores). The tank is now ready for its next use.

Several types of rinsing or flushing devices are available to assist in cleaning out wastewater holding tanks following the emptying process. Samples of these devices include wands with sprayer heads, flexi-

ble hoses with sprayer ends, rinsing drain couplers, and permanent in-tank spraying devices. When installing listed permanent in-tank spraying devices, be sure to use the provided vacuum breaker on the supply line to prevent cross connections between the fresh and wastewater systems. With the potable water and wastewater being in direct contact, if a change of potable water pressure occurred in the system, without a vacuum breaker, wastewater could be drawn into the potable water system, creating an eminent safety hazard.

Figure 6-93 Sample Fullway Termination Valves & Drains



For cleaning hardware items, such as the toilet, use a mild soap solution and hot water. Do not use strong cleaners, caustics, chlorine, or alcohol based-products, as they may harm the plastic and rubber parts in the system.

6-2.2.3.2 Gray Water Holding Tank

Upon completion of the black water dumping, the gray water tank is dumped in the same manner. The slide valve for the black water holding tank is closed, and the termination slide valve for the gray water tank is opened. Add water if necessary to effectively dump the gray water tank. After dumping, close the slide valve, fill the gray water tank with potable water, and add an approved deodorant/cleanser.

6-2.2.3.3 Holding Tank Repair

Whenever repairing a holding tank (ABS, polyethylene), first assess how the damage occurred. The cause of the damage should also be inspected. For example, if the damage was caused by road debris, the tank may

have to have protection added to keep damage from reoccurring. Holding tanks must be dumped before servicing or repairs can be accomplished.

Repairing holding tanks involves different procedures for the various other types of tanks. ABS and polyethylene are the most common plastic tanks used in the industry.

There are slight possibilities for repair if a piece of flying road debris punctures the tank or a tire disintegrates and damages the tank, for example. Cracks in the holding tank are usually a result of poor installation or stress. Cracks are usually fatigue points and are the hardest to repair because of their length or location. If a crack is located toward the bottom of the tank, the tank will probably have to be removed to repair it. Depending on the warranty, determine whether a new tank would be the best possibility before attempting to make repairs.

All tanks will flex with liquids in them, especially when the vehicle is in motion. If excessive flexing is anticipated, repairs to the tank may not hold. Also, if the plastic is several years old, it may not lend itself to repair. The two most critical factors when attempting to make any repairs are (1) the location of the crack and (2) how the tank is mounted. If the tank is secured with a strap system, determine whether the amount of straps and the quality of the material being used is sufficient to prevent the tank from excessive flexing.

Usually, 1/8 to 1-1/2 in. (3.175 to 31.75 mm) flat stock (minimum) is a sufficient strap design for securing the holding tank. The straps should be formed to fit the contour of the tank bottom while the tank is empty. Tanks must be "wedged" snugly, not tightly, between the straps and the bottom of the coach to minimize any movement when the RV starts, stops, or changes direction. There are no baffles in these tanks, so a half-full 40 gal tank will have about 20 U.S. gal, or 165 lb (74.84 kg) of liquid moving freely inside against the sides and bottom. The movement of the liquid will cause a lot of force. Again, water weighs about 8.25 lb (3.742 kg) per U.S. gallon. The average holding tank is about 35 U.S. gal, so it will weigh about 288 lb (103.4 kg) when full. Thin straps, too few straps, or supports that hold the tank from the sides will only allow a lot of expansion or flexing when it is full of water.

The main cause of most holding tank failures is stress. Sometimes tanks that are mounted too close to other components rub against them and cause stress or failure. There are also stress factors at the tank fittings. If a fitting is installed in the tank and the tank shifts, even during construction, and the fitting is in a bind, the fitting will probably crack eventually due to the constant movement of the tank while liquids are in it and the RV is in motion.

Drain fittings of tanks are often damaged by stress, especially if the drain pipes and valves are not supported correctly. The valves should be supported with brackets or supports that fasten to the RV so that when and if the valves begin to "stick" or become difficult to work with due to age, lack of lubrication on the seals, or foreign materials, the brackets will withstand the force of the consumer pulling forcefully on the valve handle. Many times, the valves and drain outlets are simply attached to the holding tanks and not supported. The pipe fittings are inserted into the tank with a sealant and then have a hose clamp around them to seal and clamp. This will not support abuse from pulling and pushing on a drain valve that is sticking or stubborn to open or close. The farther from the tank the valves are located, the more leverage can be applied to the valves, piping, and tank fittings.

Some tanks may have a portion of them exposed to the sun. This will "dry out" the plastic much faster than one that is completely concealed by the sides of the RV. Drying out will make the plastic brittle and will not allow for a patch or repair. One way to avoid this "drying out" of the plastic is to clean the plastic that is exposed and paint it. A good grade of spray paint will protect the plastic and prolong its flexibility. With tanks that have been painted, repairs will not work.

For information on repairing tanks, see *"Plastic Tank Repair" on page 6-44.*

6-2.3 Fixtures

Plumbing fixtures in the RV are quite similar to those found in conventional housing and require the same periodic maintenance and repair. Fixtures include sinks, tubs, showers, toilets, and any other receptacle or device that is intended to receive liquid or liquid-borne waste for discharge into a drainage system. While sink faucets do not require any type of sealant during installation because of the supplied gasket, sink tailpieces and threaded pipe fittings do require sealing against leaks.

NOTE: Some ABS P-traps do not require sealant at the threaded joint.

Avoid scouring powders that could scratch plastic surfaces. If a particularly difficult stain is encountered, try a Soft Scrub®-type product that is more gentle with the surface. When working with any cleaner that could possibly cause scratching, try a small amount on an area that is out of sight to be sure it will not be damage the fixture. Refer to the vehicle owner's manual for specialized cleaning instructions.

6-2.3.1 Accessibility

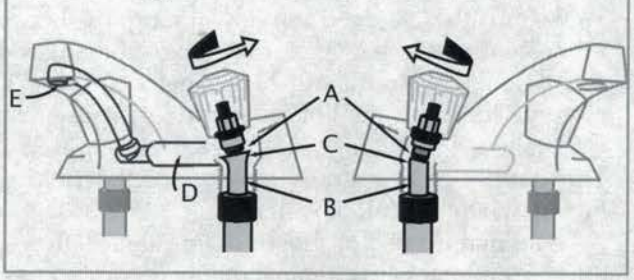
All fixtures are required to be accessible for replacement and repair. In addition, all P-traps and faucets are required to be accessible. In some cases, there are access panels for tub/shower P-traps and faucets.

6-2.3.2 Types

6-2.3.2.1 Faucets

There are two types of faucets used in RVs: the washerless type and the compression type. Either type can be installed in the kitchen (this includes faucets with and without spray hoses), shower, and lavatory. These faucets may seem to differ from each other and from brand to brand, but the basic operation is the same whether working with the washerless or compression type.

Figure 6-94 Typical Washerless Faucet

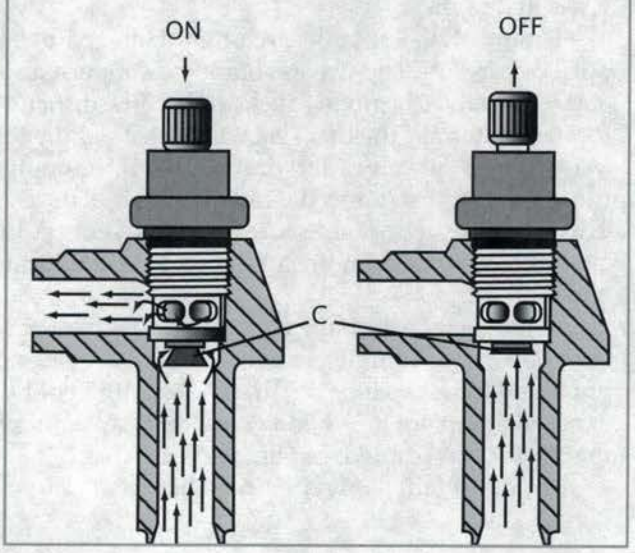


Washerless Faucets

Figure 6-94 shows a typical washerless faucet. Washerless faucets have internal O-rings that provide seals to the shafts and knobs. When the handle of the faucet is turned to the ON position, the stem tip (A) lifts up, allowing water to flow from the water lines through the shank (B). The water travels over the seat (C) and continues through the underbody (D) and out of the faucet at the spout (E).

Figure 6-95 displays an inside view of the operation of the stem in a washerless faucet.

Figure 6-95 Internal View of a Washerless Faucet



A washerless faucet will drip for one of the following reasons:

1. Debris blocking the seat, preventing the stem from proper sealing
2. Improperly aligned automatic stop
3. Normal seat wear over time
4. Breakage

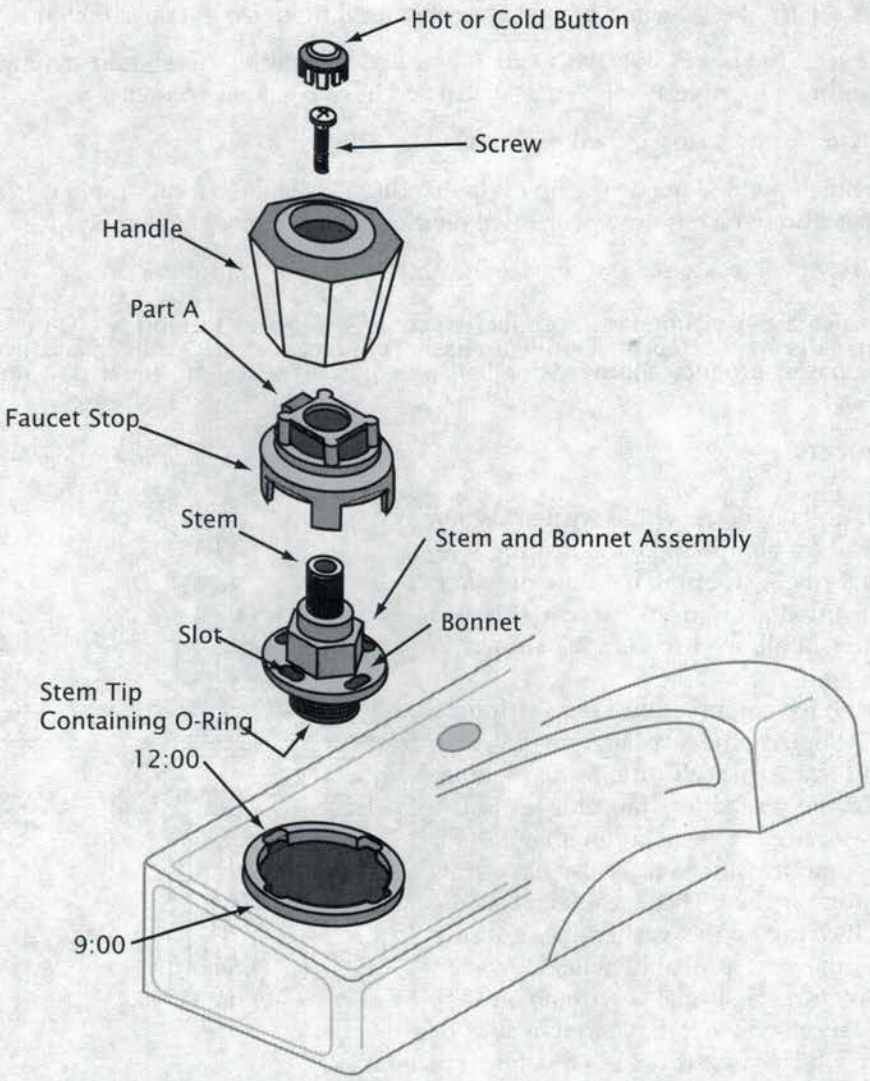
If debris is lodged in the seat (C) of the faucet, it prevents the stem from resting properly in the down position. Since the stem cannot stop the water flow with this debris clogging the seat, water will continue to dribble through, even when the handle is rotated to the OFF position.

All faucets are manufactured with automatic stops to prevent overtightening, which is the major cause of excess wear in faucets. These stops are preset at the factory for optimal performance. They can be misaligned

during installation or service. When this happens, water flow will not completely stop, even when the handle is rotated to the OFF position.

Figure 6-96 shows another view of a washerless faucet. Use *Figure 6-96* to go through the following generic steps to fix a dripping washerless faucet. Remember to use the proper service manual for any brand-specific faucet.

Figure 6-96 Assembly of a Washerless Faucet



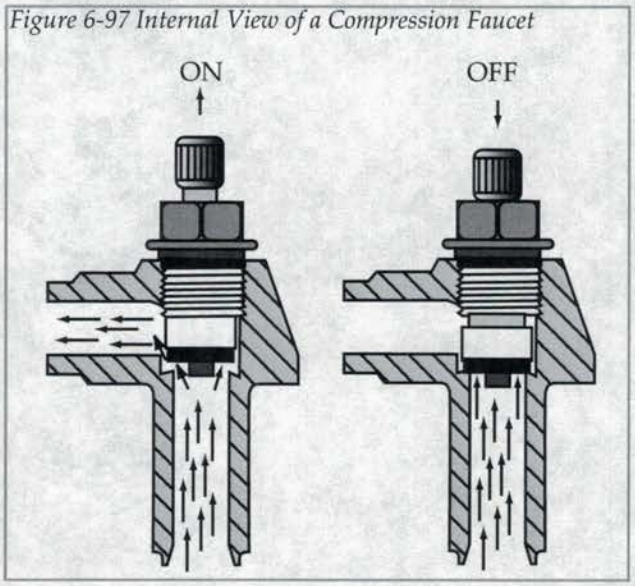
1. Turn off the water supply.
2. Unsnap the "hot" or "cold" button on the handle.
3. Remove the screw with a Phillips head screwdriver, turning the screw counterclockwise while holding the handle to keep it from rotating.
4. Lift off the handle.
5. Remove the faucet stop by placing a flat screwdriver on the side of the stop and prying it up gently.
6. Loosen the stem and bonnet assembly, sometimes called a *cartridge*, with a crescent wrench by turning it counterclockwise, and remove it by simply lifting it off with the fingers.

7. If there is foreign debris in the faucet, remove it by flushing or picking it out. Also inspect the O-rings for wear or damage. If they are OK, lubricate the O-rings and reassemble. If the O-rings are damaged, replace and lubricate them with a silicone-based product approved for use with potable water or equal.
8. Screw in the stem and bonnet assembly (cartridge) finger tight. Turn the stem to open (or counter-clockwise) position.
9. Snug up the stem and bonnet assembly with a crescent wrench. Four slots on the top of the bonnet will be noticeable. Turn the stem and bonnet assembly until tight. Do not overtighten.
10. Place the faucet stop in the slots with Part A at a 12:00 position. This should snap into place. If it does not, the slots are not properly aligned as instructed in step 8. Realign them.
11. Turn the stem clockwise to a closed position.
12. Notice the notch molded inside the lip of the handle. This is the handle stop. Position the handle stop on the faucet stop (which is now positioned on the stem and bonnet assembly).
13. Tighten the screw (clockwise) and replace the "hot" or "cold" button.

NOTE: Do not use a petroleum-based product (such as Vaseline®) to lubricate O-rings or other interior parts of the faucet. Petroleum-based products "attack" rubber and neoprene. A silicone-based product approved for use with potable water or equal is a much better choice.

Compression Faucets

Figure 6-97 Internal View of a Compression Faucet



Compression faucets operate with a washer. When the washer is pressed (or compressed) against the seat, a watertight seal is formed, stopping the flow of water. When the washer is lifted away from the seat, this seal is broken, and water is allowed to flow as shown in *Figure 6-97*.

The normal cause for compression faucet dripping is a worn washer. Replace the washer and the drip stops. The procedures are basically the same as those discussed above for the washerless faucet. Again, use the brand-specific service or installation manual for each type of faucet. Compression faucets also have seats that the washers "stop" against. These seats can become worn or damaged. If changing the washer does not stop the leak, changing the seat probably will. However, changing the seat requires a special seat removal tool. Most current RV faucets do not have removable or replaceable seats, in which case the faucets must be replaced.

When working on the faucet, also check the scree/aerator on the faucet nozzle. These can be unscrewed, cleaned, and replaced. These screens can pick up very small particles that can give a distorted water flow from the faucet.

6-2.3.2.2 Toilets

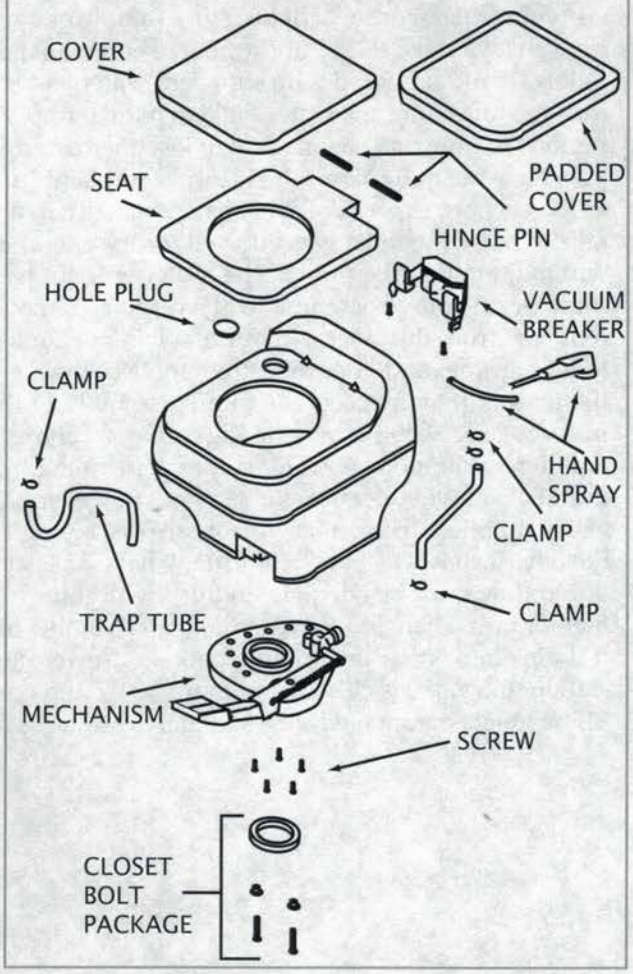
The proper installation and operation of the toilet is essential to the health and welfare of the user. Four types of toilets can be found in RVs: mechanical seal, house-type flush toilets, recirculating, and portable. These will be individually discussed below. Most toilets in the RV industry are plastic. Water seal toilets or flush toilets and some of the more expensive models are made from vitrious china.

Mechanical Seal

Mechanical seal toilets are the most common toilets used in recreation vehicles. This toilet is required to be connected directly to the body waste holding tank. The pipe connecting the toilet to the holding tank must be vertical but could use a maximum of two 45° fittings to obtain offsets around structural members of the RV if necessary. The mechanical seal toilet uses only enough water to accomplish the flush (less than one quart of water with some models). Because the piping system is never horizontal, large quantities of water are not needed as with flush toilets. The amount of flushing water used with the mechanical seal toilet is used to cleanse the bowl after use. The flushing mechanism for this type of toilet is either a hand-operated lever or a foot pedal. Some models have a separate lever for each of these functions.

A vacuum breaker (sometimes called a *backflow preventer*) is mounted at the top rear of the mechanical seal toilet. This vacuum breaker prevents the siphoning of water from the toilet into the potable water supply system of the RV. It prevents a vacuum in the toilet water supply line, eliminating the possibility of other fixtures drawing water from the toilet in the event of a pressure drop in the system. There are a number of seals in inside the vacuum breaker. If an outlet seal fails, water will leak from the vacuum breaker only when the toilet is flushed. Mechanical seal toilets do not have a separate flushing tank as found on home toilets. Water is fed directly from the RV's water system to the toilet when the toilet is flushed. *Figure 6-98* depicts a typical RV mechanical seal toilet and its component parts.

Figure 6-98 Typical RV Mechanical Seal Toilet



Specific operating instructions and service requirements are provided in the service manuals for specific models and manufacturers.

House-Type

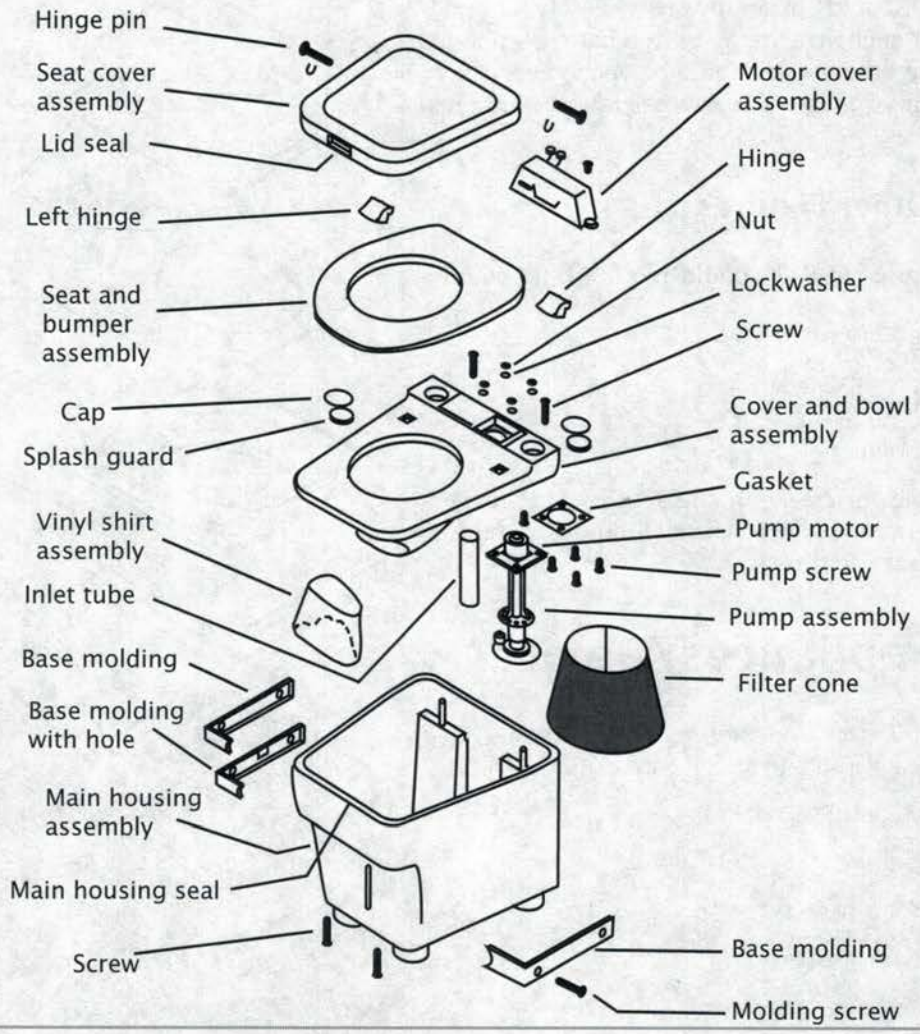
The house-type toilet is permanently mounted in the RV and flushes using water from the freshwater system, similar to the toilet in conventional housing. **These toilets are not permitted to be connected to a wastewater holding tank** because of the high volume of water involved with each flush, which could be 1-1/2 to 5 U.S. gal per flush. Instead, these toilets—often called *water seal toilets*—are designed to connect directly to a park's inground sewer system. The high volume of water associated with *water seal toilets* is necessary to move the solid body wastes through the piping system. Black water holding tanks work best with minimal water and chemicals, which work together to break down the solid waste material.

Recirculating

Recirculating toilets do not require any pressurized water source, either from the city water connection or from the potable water storage tank. They do, however, need 12 VDC to operate. To use a recirculating toilet, it must be "charged" with a supply of potable water. This charge is usually supplied by filling the recirculating toilet with about 2 or 3 U.S. gal (7 to 11 L) of water poured into the toilet from an external source. A recirculating toilet uses a 12 VDC pump and a series or system of internal piping to recirculate the water in the toilet for flushing. The liquid and solid wastes are separated, and the liquid portion is used to flush the toilet. The recir-

culating toilet is self-contained, although a holding tank can be installed to increase capacity. However, once the toilet's contents are emptied into the holding tank, the toilet must be recharged with potable water to properly function. *Figure 6-99* depicts an example of a recirculating toilet. As with all RV components and accessories, always refer to the appropriate service manual for installation, service, and repair instructions. These toilets should be stored with sufficient water and chemicals to be used. The chemicals will help clean and sanitize the toilet, and the water will keep the pump and O-rings from drying out. If the toilet is unused for long periods of time, the chemicals will lose their strength, and the toilet should be emptied and "recharged" with potable water and chemicals. Typical complaints of this toilet include excessive odors, especially when the toilet is reaching capacity. Problems are usually in a pump system. For example, the motor is often blamed or fails because the toilet was allowed to dry out, and there will always be some solids, particularly tissue, that will migrate into the pump. The motor will not be able to rotate against the dry, then wet tissue particles. In this case, the pump assembly will have to be removed and everything in it broken down and cleaned. It can be removed from the toilet without removing the toilet from the bathroom. It will have screws mounting it to the toilet housing, and after they are removed, the assembly can be lifted straight up. There is a hose attached at the bottom that connects the pump assembly to the toilet bowl, and it must be disconnected. Plastic gloves must be used when removing the clamp and hose. Obviously, draining, refilling, and draining the toilet several times with potable water before performing this procedure is highly recommended. The motor is usually durable and will tolerate a lot of abuse; however, it must have adequate voltage to operate. If insufficient voltage is supplied, the motor will not turn fast enough, and not enough liquid will be pumped to the bowl to adequately flush it. The bowl will usually have a plastic membrane or trap to keep most odors from escaping. The liquid flow must be adequate to flush with some force to move the solids and push them through the traps or membranes. There is a valve at the bottom of the toilet, and this valve must be opened to drain the toilet. After it drains into either the holding tank or a sewer hose to a proper receptacle such as a sewage outlet or dump station, the valve is closed, and more water and chemicals are put into the toilet. It is then ready to use again. These toilets mount on a closet flange, the same as flush and mechanical toilets.

Figure 6-99 Typical RV Recirculating Toilet



Portable Toilets

Portable toilets are most often used in smaller recreation vehicles that are not equipped with drainage systems. Typical RVs using portable toilets are folding camper trailers and truck campers. Waste storage capacity is very limited, and frequent dumping is required. Portable toilets as depicted in *Figure 6-100* usually consist of a top half (bowl, seat, and flush water reservoir) and a bottom half (slider valve and handle, waste holding tank, and dumping tube). To use this toilet, potable water is introduced into the freshwater tank, or the upper section of the toilet, through a fill fitting. This water does not need chemicals, as it is only used to flush the bowl. The lower tank, or waste holding tank, will need some chemical to accelerate solid disintegration, sanitize, and prevent excessive odors. After the toilet is used, the drain valve is opened, and the consumer will push on the bellows to pump the potable water around the bowl until it is either pushed or pulled, depending on whether it has a foot-operated pedal or a hand-pulled gate valve. This opens the passage from the toilet bowl to the holding tank. Obviously, this type of unit will fill quickly. When it is full, the holding tank portion of the toilet can be detached from the upper portion and carried to a campground toilet or receptacle and dumped in, flushing it while slowly dumping the contents. After dumping (with the pour-out spout), the toilet is reassembled, the upper tank is refilled with potable water, and chemicals are added to the lower holding tank.

NOTE: Care must be taken when using these toilets after changing elevation—for example, leaving a lower elevation and going to a higher one.

This change in elevation will pressurize the holding tank portion, since it is sealed, and when the valve is first opened, it could spray upward violently, depending on elevation change, along with whatever contents are inside. The drain valve should be opened very, very slowly until it equalizes the new elevation's air pressure.

6-2.3.2.3 Other Fixtures

These fixtures in RVs should require little maintenance:

- Tubs
- Sinks
- Showers

Repair holes or cracks in sinks, tubs, and showers using the fiberglass patch repair method described earlier, or replace the fixture.

6-2.4 Appliances/Devices

These appliances and devices should be installed according to the specific product instructions:

- Accumulators
- Regulators
- Water heaters
- Dishwashers
- Clothes washers
- Garbage disposals
- Ice makers
- Water filters/purifiers
- Waste tank flushing systems

A separate textbook is devoted to water heaters. The rest of these devices should be installed or repaired by referring to the specific product installation or repair manual.

These accessories are usually connected to the water distribution system piping with a pipe fitting using the standard PB or PEX connection shown in *Figure 6-101*. Remove and replace these devices by removing and reattaching the water distribution system tubing to the new device. If the pipe fitting needs replacement, cut it off and replace it using the PB or PEX installation procedure outlined previously. (See the specific manufacturer's installation guide.)

Figure 6-100 Typical RV Portable Toilet

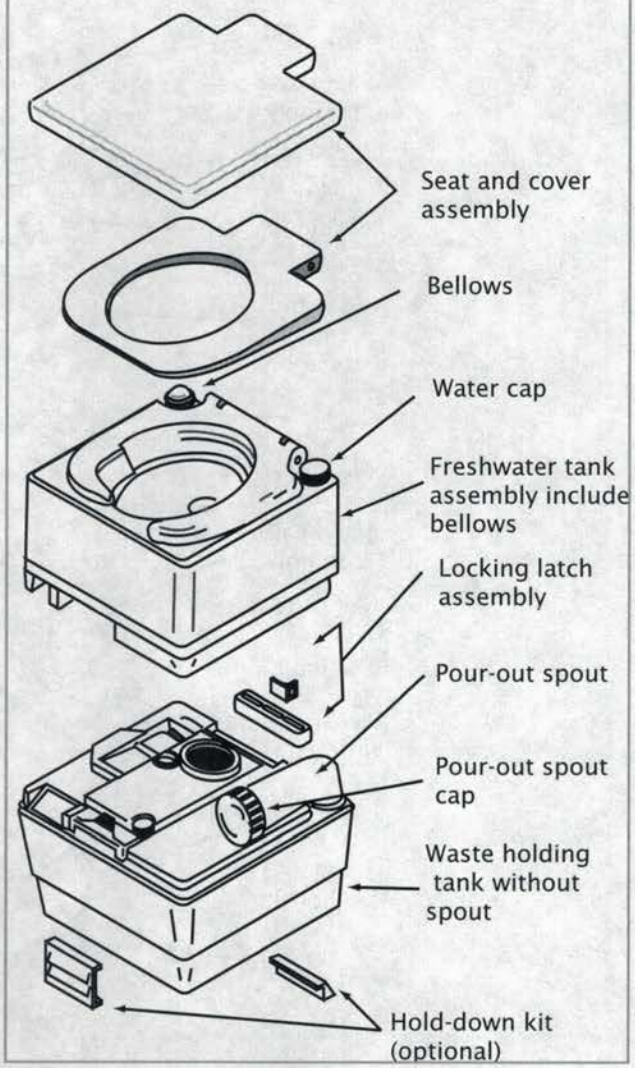
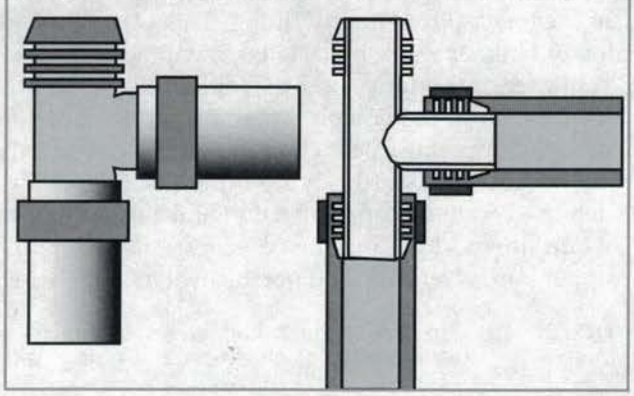


Figure 6-101 PB/PEX Fitting Connection to the Piping



6-2 Review

1. List the three manufacturing methods for PEX piping.

   A.

   B.

   C.

2. Is the piping from these three manufacturing methods compatible with the others?

   Yes No

3. Rigid piping is connected/assembled using the crimp method.

   True False

4. Freshwater storage tanks are exempted from the requirement to be vented.

   True False

5. The typical water pressure created by a demand water pump is _____ psi.

   A. 20

   B. 40

   C. 60

   D. 80

6. Most water pumps are mounted horizontally.

   True False

7. Water pumps can "pull" better than they can "push."

   True False

8. Proximity of the water pump to the storage tank is immaterial to its operation.

   True False

9. Water pumps work better if they are mounted at the same level as the bottom of the storage tank.

   True False

10. Water pumps should never be mounted on wood.

    True False

11. Piping size required to connect the potable water supply to the distribution system is determined by _____.

    A. Inside diameter of the piping

    B. Outside diameter of the piping

    C. The length of the water system

    D. The number of fixtures

12. The electrical wire gauge used in installing a water pump remains constant regardless of the length of the line.

    True False

13. Which of the following is/are not true?
    A. Sealants should never be used on flare fittings, compression fittings, and compression rings.
    B. Teflon® tape is approved for use in water systems.
    C. Pipe joint compound must be nontoxic and insoluble in water.
    D. Any type of thread lubricant may be used.
    E. Sealants are used on both the male and female threads of a connection.
14. Which of the following is the most probable cause of a water pump periodically running (cycling) when all fixtures are turned off?
    A. The water tank is almost empty.
    B. The inlet line to the water pump is clogged.
    C. There is a water leak in the system.
    D. Air is leaking into the inlet hose fittings.
15. Non-demand water systems use a small electric water pump, a faucet, and a switch.

    True False
16. Non-demand electric water pumps are of the _____ design.
    A. Pressurized
    B. Vacuum
    C. Gravity
    D. Impeller
17. A _____ must be located at any city water service connection if the water distribution system has a non-pressurized water tank and is connected to city water.
    A. Pressure gauge
    B. Pressure relief valve
    C. Check valve
    D. Emergency cutoff valve
18. When hanging piping in the drainage system, support the piping every _____ feet (centimeters).
    A. 2 (60.96)
    B. 4 (121.9)
    C. 6 (182.9)
    D. 8 (243.8)
19. When dumping wastewater at an appropriate dump station, always:
    A. Dump the gray water holding tank first, then the black water holding tank.
    B. Dump the black water holding tank first, and then the gray water holding tank.
    C. Dump both wastewater holding tanks at the same time.
    D. Rinse both holding tanks at the same time.

20. List the two types of faucets used in RVs.

    A.

    B.

21. List the four types of toilets used in RVs.

    A.

    B.

    C.

    D.

22. Holes or cracks in sinks, tubs, and showers are usually repaired using the _____ method.

    A. Plastic welding

    B. Fiberglass patch

    C. Plastic patch

    D. Ceramic paint

23. Explain the purpose of a vacuum breaker.

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Chapter

6-3 Testing Completed Systems

6-3.1 Drainage and Distribution

This chapter contains information on how to perform a flood test, retarded flow test and pressure test. Use the following procedures to complete these tests.

6-3.1.1 Drainage

6-3.1.1.1 Fixture Flood Level Test

Use the following procedure to test the drainage system for leaks:

1. Fill the entire drainage system, including wastewater holding tanks until water is visible in the bottom of the lowest fixture on each system. (Usually the tub/shower for a gray water tank system and/or the toilet for the black water system.)
2. Visually check all piping and tanks for leaks.

Black Water System Flood Test

The recreational vehicle shall be in a level position, all fixtures shall be connected, and the entire system shall be filled with water to the flood level of the toilet bowl. (Tub and shower drains shall be plugged) After all trapped air has been released, the test shall be sustained for not less than 15 minutes. The waste piping above the level of the toilet shall be tested and show no indication of leakage when the high fixtures are filled with water and emptied simultaneously to obtain the maximum possible flow in the drain piping.

Gray Water System Flood Test

When a recreational vehicle is equipped with a liquid waste holding system, it shall be subjected to a static water test for 15 minutes by filling the system with water to the flood level of the lowest fixture without evidence of leaks.

6-3.1.1.2 Flow Test

Perform this test as follows:

1. Plug all fixture drains and fill all fixtures 1/2 full with water.
2. Open the drains for each fixture. Observe the water in each fixture to ensure the flow is even and not retarded (slow flowing).
3. Check all fittings and P-traps for leaks.

6-3.1.2 Distribution

6-3.1.2.1 Pressure System Tests

Air Pressure Test

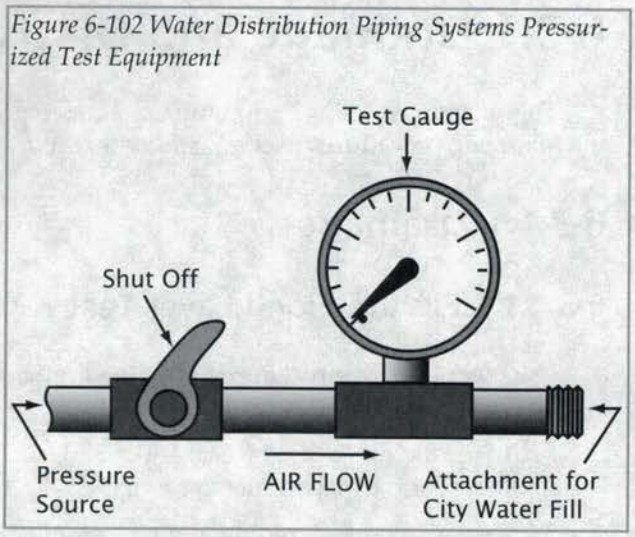

Figure 6-102 Water Distribution Piping Systems Pressurized Test Equipment

STEP 1:

Isolate the water heater from the pressurized water distribution system by using the water heater bypass valve, if provided. If these valves are not present, create a temporary bypass by disconnecting the hot and cold water lines at the back of the water heater and connecting them together.

STEP 2:

Pressurize the system with air only to 80 psi (551 kPa), or as directed by the piping materials manufacturer, if CPVC piping is used. The test pressure should be applied at the city water connection.

STEP: 3

After the system is pressurized, disconnect the pressure source and monitor the test gauge for a minimum test period of 10 minutes. A successful test will show no pressure drop or leak. If pressure drop is noted, repair the piping, then retest until no pressure drop is noted.

STEP 4:

Remove the temporary bypass and reconnect the water heater lines to their original configuration

NOTE: When testing with air only, use extreme caution. Air pressure can be dangerous if water lines, fittings, or devices should rupture when under test.

Demand System Test

Vehicle with demand systems shall be permitted to be tested by subjecting the system to water to the maximum discharge pressure (cut-off pressure) listed on the pump for a period of 10 minutes without leakage or loss of pressure.

6-3 Review

1. List the three types of system checks performed on the RV waste drainage systems.

   A.

   B.

   C.

2. What type of tests could the technician perform on the water distribution system?

   A.

   B.

3. In these tests (question 2), how long should the test period last?

4. What type of test requires that the entire drainage system, including the holding tanks, are filled until water appears at the bottom of the lowest fixture on each system?

5. What type of test requires that each fixture drain be opened and water level visually observed?

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Chapter

6-4 Winterization

The entire water system in the RV, including toilets, needs to be winterized before storage in freezing climates. This will prevent water from freezing and damaging the lines, pipes and fixtures. There are several procedures for winterization. The goal is to replace all of the water in the system with a nontoxic antifreeze. Once this is accomplished the unit will be safe to store for winter.

Nontoxic antifreeze must be compatible with potable water systems and is readily found at RV parts stores, hardware stores and camping supply stores. It is usually available in two grades that are rated for different temperatures. Make sure the antifreeze being used will be satisfactory for the ranges of temperatures in the region. If customers are going to be travelling to a colder climate, ensure that the grade used will be satisfactory for their destination.

NOTE: Draining of a water system is not adequate to be sure that there will be no problems with freezing and bursting of lines, pipes or components. The pump, toilet valve and city water inlet do not drain.

6-4.1 Winterizing the Water System Using Nontoxic Antifreeze

NOTE: Use only nontoxic antifreeze designed for potable RV water systems.

If nontoxic antifreeze is chosen for winterization of the freshwater system, installation of a hot-water tank bypass kit will avoid having to fill the entire water heater with antifreeze. Some units will be equipped with a water heater bypass system. With others it may be beneficial to suggest to the customer that a bypass system be installed when the coach is winterized. On other systems a temporary bypass can be used when winterizing the coach. In all cases before proceeding ensure that the freshwater tank and the water heater have been drained.

To install a temporary water heater bypass, the hot and cold lines to the hot water tank need to be disconnected. Be aware that there will be still some water in the water heater. The drain is located higher up then the cold inlet. Be prepared to catch this water in a shallow container or with towels, etc. Once the hot and cold lines are disconnected, connect the two hoses together. This may require a small length of hose and several fittings to make the connection.

There are two reasons for bypassing the water heater. The first is that the water heater design when drained will not allow for the unit to be damaged by freezing. If the water heater is not bypassed it would require enough antifreeze to fill the tank. This would be expensive and a waste. The second reason is the steel glass lined tanks use an anode rod as a sacrificial metal. This anode rod is affected by antifreeze and will actually start to disintegrate.

6-4.1.1 Winterizing Procedures

1. Drain Water Completely - As previously discussed, most RVs are equipped with low point drain valves for both the hot and the cold lines. Usually located at the lowest point in the RV, these valves aid in gravity draining as much water as possible from the lines. Valve positioning may be located at or below the floor level. Some are found underneath the chassis. Others may not be valves at all, but rather simple pipe plugs (*Figure 6-103*).

   Accessories such as a "blow out plug" which attaches to the city water inlet are readily available. Open all the faucets and drain valves and screw the blow out plug into the city inlet and apply compressed air.

NOTE: Be sure to use "clean" air. Many shop air compressors have a contaminated air supply.

Existing water must be removed from:

A. Freshwater Storage Tank - Drain the water from the storage tank in the usual manner. Drain valves may be located on the outside of the coach, inside a compartment or underneath the chassis.

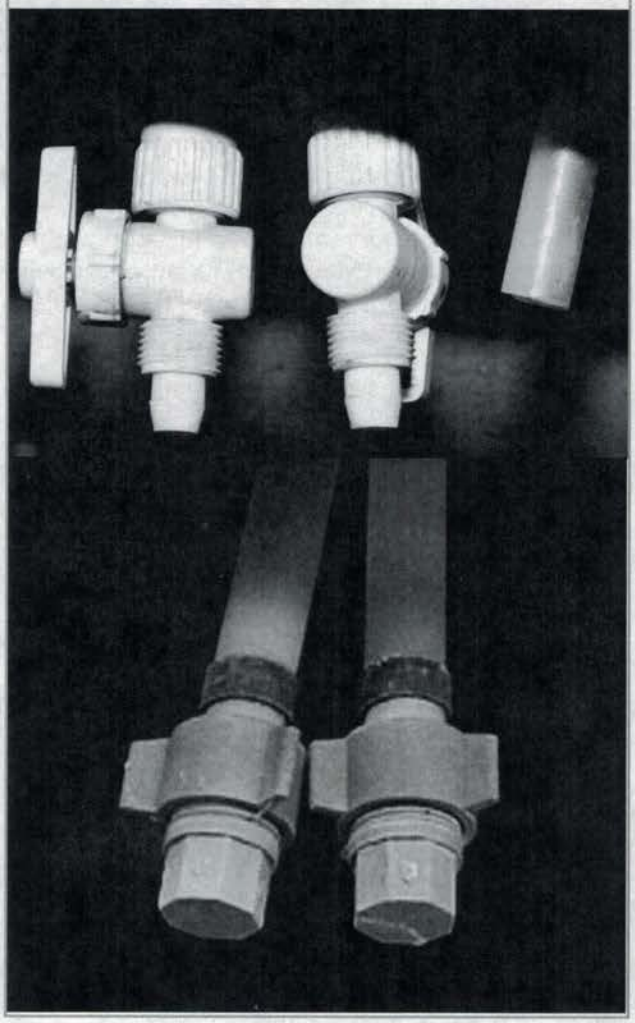
B. Water Heater - As discussed earlier, completely drain the water heater and activate the bypass valves to isolate the water heater from the remaining freshwater system.

C. Toilet - Regardless of which type of toilet is found in the RV, it will be necessary to remove all water from it. Usually, it is just a simple matter of operating the flushing mechanism. Refer to the product manufacturer's written instructions.

D. Shower - An area that seems to often get overlooked during the winterizing procedure is the shower hose. Even though it is equipped with an anti-siphon backflow preventer which typically drains residual water, many times water stays trapped in the shower hose. Simply unscrew the hand-held showerhead and lower the hose to a point below the faucet attachment point.

E. Icemaker - Another overlooked section of freshwater piping that can be damaged is the tubing leading to an icemaker (if equipped). Remove the tubing at the connection to the icemaker and fully drain all residual water from the hose and the inlet valve.

Figure 6-103 Low-Point Drain Valves and Plugs



F. Washer Inlet - Remove the water hoses from the clothes washer (if equipped) and ensure all water has been removed from the lines.

G. Exterior Showerhead - Many RVs are equipped with outside faucets or a showerhead for rinsing off dirty feet before entering the RV. Do not overlook the importance of draining this exterior fixture as well.

2. Winterizing the Freshwater System - After the lines have been blown dry or totally drained, add an appropriate amount of RV antifreeze solution.

NOTE: Verify the antifreeze is RV antifreeze! Standard automotive antifreeze contains poisons that will contaminate the freshwater system.

There are two basic methods of adding the antifreeze to the system.

- Water Pump Method
- Backfill method

The water pump method involves filling the freshwater storage tank with the appropriate amount of antifreeze (approximately two gallons or more depending on the size of the system), and then simply pumping it through the entire freshwater plumbing system using the onboard demand pump. After

pouring the antifreeze into the tank, turn on the water pump and open all the hot and cold faucets. Make sure the water heater bypass kit is in the bypass mode. When the antifreeze appears at each faucet, the showerhead and at the toilet, close the faucets and turn off the pump.

The backfill method invokes the use of a hand-operated pump that attaches to each individual faucet. Antifreeze is hand pumped directly from its container into the system. This method takes longer, but can be just as effective, especially on smaller campers and travel trailers.

In addition, kits are available that are comprised of a permanently mounted auxiliary tank just for RV anti-freeze. Some may even be equipped with a dedicated pump to distribute the liquid throughout the piping system. In the shop, many RV technicians will use a separate "shop" pump to force anti-freeze through the system via the city water inlet.

3. Winterizing the Waste System

During the course of pumping the antifreeze throughout the freshwater system, chances are anti-freeze was also introduced through the "P" traps and into the waste system. The black and gray water holding tanks and all drains must also be prepared for storage and winterizing.

"P" Traps - As mentioned, the "P" traps probably have antifreeze in them already, but to be sure, pour another cup down the drain at the kitchen and lavatory sink and also in the shower/tub drain.

Holding Tanks - Flush and clean all holding tanks. After cleaning, drain each tank and close the termination valves completely. If the valves are sticking or are hard to slide, disassemble them and apply a light coating of a silicone-based lubricant to both sides of the blade to ensure smooth operation come spring.

6-4 Review

1. Nontoxic antifreeze only comes in one grade.

   True False

2. Draining the water system is an acceptable way of winterizing the RV.

   True False

3. What is required to avoid having to fill the entire water heater with antifreeze?

   A. hot water tank check valve bypass

   B. anode valve bypass kit

   C. hot water tank siphon hose valve

   D. hot water tank bypass kit

4. Which of the following is a valid reason for NOT putting antifreeze into a water heater.

   A. The antifreeze will corrode the glass liner.

   B. The antifreeze will disintegrate the anode rod.

   C. The antifreeze will contaminate the water heater.

   D. The antifreeze will disintegrate the hoses.

Chapter

6-5 RV Plumbing System Codes and Standards

6-5.1 Industry Codes and Standards

Industry codes and standards have been developed to ensure safety and to reduce liability. The major source of RV standards are the *NFPA 1192* and *CSA Z240*. These standards outline requirements for plumbing, heating (propane system), fire and life safety, and electrical.

The RVIA (Recreation Vehicle Industry Association) requires that member manufacturers agree to in-plant visits by the RVIA inspectors. If members refuse or fail to comply, they can be expelled and, therefore, lose the right to bear the association's seal of membership.

To help everyone better understand the requirements of the standard, an industry handbook is maintained by RVIA. Industry stakeholders work with RVIA to document the enforcement positions, which explains the standards in detail. Although standards are primarily designed for RV manufacturers, it is important from a liability standpoint that RV service technicians strive to follow these standards where possible when modifying, servicing, or installing RV systems or their components.

Agencies, state and private, involved with RV safety training use and follow the NFPA and CSA standards for Recreational Vehicles. This NFPA standard is revised every three years, with dates being 2002, 2005, 2008, 2011, and so on. Industry always begins using the new edition of the NFPA requirements on or near May 1 of the revision year, and manufacturers must comply with requirements by September 1 of the new code edition year.

6-5.2 Code Summary

Table 6-5 is a summary of the current RV standard that pertains to the normal duties of the RV service technician. This summary is provided as a quick reference, NOT AS A SUBSTITUTE FOR THE ACTUAL STANDARDS. Once the reference in these tables has been found, go to the referenced standard for the exact wording, and use the handbook for the detailed explanation.

The *NFPA 1192 Standard for Recreational Vehicles*, RVIA's NFPA 1192 Handbook, *A Guide to NFPA 1192*, and *ANSI/RVIA 12 V Standard for Low Voltage Systems in Conversion and Recreational Vehicles* are available at www.rvia.org. The *National Electrical Code* is available from NFPA at www.nfpa.org/catalog/ or by calling 1-800-334-3555.

Information on CSA Standards can be obtained by going to their website at www.shopcsa.ca.

Table 6-5 Plumbing—Applicable to RV Service Technicians

Service Technicians Task	2008 CSA Z240	2011 1192	Summary of Requirement
Inspect/Repair Water Tanks	4.7.2	7.3.7	Freshwater holding tanks shall not be subject to road damage. Also, non-pressure or gravity tanks shall be vented at the top of the tank.
Replace City Water Fill	6.2.5	7.3.9	City water fills shall be equipped with a backflow preventer or check valve.

Table 6-5 Plumbing—Applicable to RV Service Technicians

Service Technicians Task	2008 CSA Z240	2011 1192	Summary of Requirement
Inspect/Repair Water Distribution System	5.2	7.1.2.1	Materials, devices, fixtures, fittings, equipment, and appliances of the water system shall be listed.
Inspect/Repair Showers	4.1.7	7.2.4.3	Seal shower enclosures to a minimum height of 70 in. (1778 mm). Doors, tubs, and enclosures, if glazed, shall meet the requirements of ANSI Z97.1.
	4.1.7	7.3.9	Exterior showers shall have internal vacuum breakers.
Inspect/Repair/Replace Waste Storage Tanks	7.6.3	7.5.1	Waste holding tanks shall be accessible for replacement and repair without removal of permanent structural members.
	7.6.3	7.5.4	No connection shall be made between liquid and body waste holding tanks upstream from fullway valves.
	7.3	7.5.2.3	The drain opening for the liquid tank shall be a minimum of 1-1/2 in. dia and located at the lowest point of the tank.
	7.6.2.3	7.5.2.5	The liquid holding tanks shall be vented through the roof with a minimum 1-1/4 in. pipe diameter.
	7.6.3.2	7.5.3.4	Body waste tanks shall have a minimum 3 in. drain opening located at the lowest point of tank. A fullway valve is required within 36 in. (914.4 mm) of the holding tank.
	7.6.3.3	7.5.3.6	Body waste tanks shall be vented through the roof with a minimum 1/4 in. pipe diameter.
Inspect/Repair/Replace Drainage Piping System	7.4.1	7.4.3.3	Horizontal-to-horizontal and vertical-to-horizontal drain connections require long turn-type fittings.
	4.4.2.1	7.4.8.2	Cleanout openings shall be located such that a cleanout tool is not required to pass through more than 360° of turns.
	4.4.2.2	7.4.8.3	6 in. (152.4 mm) clearance is required in front of cleanout openings.
	7.5	7.4.2.4	1/8 in. (3.175 mm) per foot (30.48 cm) of slope is required for drains.
	8.1	7.6.1.1	All traps are required to be vented.

Table 6-5 Plumbing—Applicable to RV Service Technicians

Service Technicians Task	2008 CSA Z240	2011 1192	Summary of Requirement
Inspect/Repair/Replace Drainage Piping System	7.4	7.6.5.1	Other than wet vents, horizontal vents shall be a minimum of one vent pipe diameter above the flood level of lowest fixture on that drainage system.
	4.1.5	7.6.6	Anti-siphon trap vent devices shall be accessible for replacement and repair.
	8.11.1	7.6.8.1	Waste holding tank vent terminations shall be a minimum of 3 ft (91.44 cm) from motor-driven air intakes.

NOTE: There is no review for this chapter.

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6 Answer Keys

Chapter 6-1

1. A. To supply potable water (both hot and cold) *(page 6-1)*
   B. To provide a means of disposing of wastewater used at each fixture in a sanitary manner *(page 6-1)*
2. Both the water distribution and wastewater systems are usually self-contained in that the RV has both an onboard source of water and an onboard means for storage for waste *(page 6-1)*.
3. A. False. It is called ABS (acrylonitrile-butadiene-styrene). PVC is used in the housing industry *(page 6-1)*.
   B. True. However, it can be white *(page 6-1)*.
   C. True. *(page 6-1)*
   D. False. Fittings have the information embossed into the plastic, normally on the body of the fitting away from the hubs *(page 6-1)*.
4. C. *(page 6-1)*
5. C. *(page 6-1)*
6. D. *(page 6-1)*
7. A. Piping system *(page 6-2)*
   B. Freshwater storage tank
   C. Water heater
   D. Water pump
   E. Faucets

   These are the major components. Other components may be included.
8. "Listed" means that equipment or materials have been tested and evaluated and are suitable for the application for which they are to be used *(page 6-4)*.
9. A. A source of freshwater *(page 6-4)*
   B. A means of providing pressure
10. A. City water pressure *(page 6-5)*
    B. Demand pump pressure system *(page 6-5)*
    C. Manual pump system (creates own pressure) *(page 6-5)*
    D. Air pressurized system *(page 6-5)*
11. C. *(page 6-6)*
12. E. While PB is not now available as a type of piping, it is still in use in many RVs built prior to 1996 *(page 6-8)*.
13. False. Copper tubing may be used. It can sometimes be found in older RVs or high-end (expensive) RVs *(page 6-9)*.
14. Three. Freshwater storage tank *(page 6-9)*, liquid waste holding tank (gray water) *(page 6-9)*, and the body (solid) waste holding tank (black water) *(page 6-9)*. A single holding tank sometimes may be used to store both liquid waste and body waste.
15. False. PVC can be used for RV drainage systems but seldom is, because the material is more brittle in cold weather. Portions of the RV drainage system are exposed to outside weather conditions *(page 6-10)*.
16. *NFPA 1192 Standard for Recreational Vehicles* *(page 6-1)*
17. True. *(page 6-11)*
18. False. *(page 6-11)*
19. D. Accumulator *(page 6-15)*
    E. Pressure gauge *(page 6-18)*
    B. Filter *(page 6-16)*
    C. Check valve *(page 6-17)*
    A. Regulator *(page 6-16)*
20. A P-trap provides a water seal preventing gases from escaping into the RV *(page 6-10)*.

Chapter 6-2

1. A. Engel method (Type A) *(page 6-23)*
   B. Silane method (Type B)
   C. Radiation method (Type C)
2. No. When replacing PEX piping, make sure that the PEX material to be used is a type compatible with another type if being mixed *(page 6-24)*.
3. False. Rigid piping, such as CPVC, is assembled using plastic pipe solvent. Crimping may be used on such piping as copper tubing and PB *(page 6-35)*.
4. False. Venting of freshwater storage tanks is required to allow air to escape during filling *(page 6-47)*.
5. B. *(page 6-48)*

6. True. *(page 6-50)*
7. False. Water pumps can "push" better than they can "pull" *(page 6-50)*.
8. False. The closer to the storage tank, the better. Distance can cause the water pump can cause "starvation" of water supply *(page 6-50)*.
9. True. *(page 6-50)*
10. False. Water pumps should be mounted on wood, as wood damps the noise of operation. Mounting on metal increases the probability of increased noise and vibration *(page 6-50)*.
11. D. The number of fixtures determines the piping size, which is measured by inside diameter and outside diameter for tubing and pipe size for iron pipe *(page 6-51)*.
12. False. The gauge will change as the length of the line increases; 14 ga up to 20 ft (6 m), 12 ga from 20 to 50 ft (6 to 15.24 m), and 10 ga over 50 ft (15.25 m) *(page 6-50)*.
13. A. True. *(page 6-51)*
    B. True. *(page 6-51)*
    C. True. *(page 6-51)*
    D. False. Thread lubricant has the same requirements as pipe joint compound and must be identified as being acceptable for use with potable water *(page 6-51)*.
    E. False. Sealants are only applied to the male threads *(page 6-51)*.
14. C. *(page 6-55)*
15. True. *(page 6-59)*
16. D. *(page 6-59)*
17. C. *(page 6-59)*
18. B. 4 ft (121.9 cm) (See paragraph 7.4.2.5, *NFPA 1192*) *(page 6-40)*
19. B. *(page 6-67)*
20. A. Washerless faucets *(page 6-70)*
    B. Compression faucets
21. A. Mechanical seal *(page 6-72)*
    B. House-type flush
    C. Recirculating toilets
    D. Portable toilets
22. B. *(page 6-76)*
23. A device to provide backflow protection, preventing siphoning of potentially contaminated water into the freshwater supply *(page 6-41)*

Chapter 6-3

1. A. Black water system flood test *(page 6-81)*
   B. Gray water system flood test *(page 6-81)*
   C. Flow test *(page 6-81)*
2. A. Air pressure test *(page 6-82)*
   B. Demand system test *(page 6-82)*
3. 10 min *(page 6-82)*
4. Fixture flood test *(page 6-81)*
5. Flow test *(page 6-81)*

Chapter 6-4

1. False. It comes in two grades that are rated for different temperature ranges *(page 6-85)*.
2. False. Draining of a water system is not adequate to be sure that there will be no problems with freezing and bursting of lines, pipes, or components. The pump, toilet valve, and city water inlet do not drain *(page 6-85)*.
3. D. *(page 6-85)*
4. B. *(page 6-85)*

Chapter 6-5

There is no review for this chapter.

6 Glossary of Plumbing Terms

ABS A high-strength plastic material used for drains and vents. ABS stands for acrylonitrile butadiene styrene.

Accessible As applied to a fixture, connection, appliance, or equipment—having access thereto, but such access may require the removal of an access panel, door, or similar obstruction.

Air Gap The unobstructed vertical distance through the free atmosphere between the opening from any pipe or faucet supplying potable water to a tank, plumbing fixture, or other device and the flood-level rim of the receptacle.

Anti-siphon Trap Vent Device A device that automatically opens to admit air to a fixture drain above the connection of the trap arm so as to prevent siphonage. This device closes tightly when the pressure within the drainage system is equal to or greater than atmospheric pressure so as to prevent the escape of gases from the drainage system into the recreational vehicle.

Backflow The flow of water or other liquids, mixtures, or substances into the distributing pipes of a potable supply of water from any sources other than its intended source.

Backflow Preventer A device or means to prevent backflow.

Body Waste The discharge from any fixture, appliance, or appurtenance containing fecal matter or urine.

Branch Any part of the piping system other than a riser, main, or vent stack.

Branch Vent A vent connecting one or more individual vents with a vent stack.

Check Valve A mechanical valve that permits the flow of liquid in only one direction. A type of backflow preventer.

City Water Service Connection The 3/4 in. female swivel connection or point of connection on the vehicle designed for connection of the RV's potable water distribution system from an external potable water supply.

Combination Compartment A shower stall or receptor that includes a toilet or washbasin (lavatory).

Common Vent Vent connecting at the junction of fixture drains and serving as a vent for more than one fixture.

Continuous Vent A vertical vent that is a continuation of the drain to which it connects.

Continuous Waste A drain from a maximum of two fixtures connected to a single trap.

Cross Connection Any physical connection or arrangement between two otherwise separate systems or sources, usually one of which contains potable water and the other wastewater.

Diameter The nominal inside or outside cross-sectional dimension of a pipe or tube.

Drain A pipe that carries waste, water, or liquid-borne wastes in a drainage system.

Drain Hose A hose used for connecting the liquid or body waste drain outlet to a sewer inlet connection.

Drain Outlet The lowest end of a main or secondary drain to which a sewer connection is made.

Drainage System All piping within or attached to the structure that conveys body or liquid waste to the drain outlet or outlets.

DWV Drain, waste, and vent.

Fixture Drain The drain from a fixture's trap to the drain outlet or to the junction of that drain with any other drain pipe.

Fixture Supply The water supply pipe connecting a fixture to a branch water supply pipe or directly to a main water supply pipe.

Fixtures (Plumbing) Receptacles, devices, and appliances that are supplied with water or that receive liquid or liquid-borne wastes for discharge into the drainage system.

Flexible Drain System An assembly that consists of a trap, strainer, hose, and connectors for use as a liquid waste drainage system.

Flood Level The level in the receptacle over which water would overflow to the outside of the receptacle.

Flooded The condition that results when the liquid in a container or receptacle rises to the flood level.

Fullway Termination Valve A valve that, when fully opened, has a non-fouling passageway not less than the inside diameter of connected piping. Also called *gate valve, knife valve, slide valve, blade valve,* or *dump valve.*

Grade See definition of "slope."

Horizontal Branch A drainpipe extending laterally that receives the discharge from one or more fixture drains and connects to the main drain.

Horizontal Pipe A pipe or fitting that forms an angle of 45° or less with the horizontal.

Individual Vent A pipe or anti-siphon trap vent device installed to vent a single fixture drain.

Liquid Waste The discharge from any fixture, appliance, area, or appurtenance that does not contain body waste.

Main The principal artery of the system to which branches may be connected.

Main Drains The lowest piping of a drainage system that receives the liquid or bodily waste discharge from all the fixtures within the system and conducts these wastes to the drain outlet(s).

Manual Disconnect A joint or connection that can be disassembled without tools.

Pitch (or Grade) See "Slope."

Potable Water Storage Tank A tank installed in a recreational vehicle for the purpose of storing potable water.

Primary Vent The main vent of the vent system, which is open to the outside atmosphere.

Secondary Vent Any vent other than the primary vent or those serving toilet or holding tanks.

Side-Vented Drainage System A liquid waste drainage system utilized in conjunction with a one- or two-compartment sink, lavatory fixture, or shower.

Slope A grade or fall of a line of pipe in reference to a horizontal plane. In drainage, it is usually expressed as the fall as a fraction of an inch (or mm) or percentage slope per foot (or meter) length of pipe.

Stem & Bonnet Compression Type Components of a faucet used to control the flow of water by forcing a rubber washer against the seat.

Toilet—Flush (Water Closet) A toilet that conforms with ANSI/ASME A112.19.2M or ANSI Z124.4.

Toilet—Mechanical Seal A toilet fitted with a water-flushing device and a mechanically sealed trap.

Toilet—Recirculating Chemical A self-contained, recirculating toilet in which the waste is chemically treated.

Toilet—Trap Arm The piping between the toilet and its vent that receives the discharge from each toilet.

Trap A fitting or device designed and constructed to provide a liquid seal that will prevent the back passage of air without materially affecting the flow of liquid waste through it.

Trap Arm That portion of a fixture drain between a trap and its vent.

Trap Seal The vertical depth of liquid that a trap will retain.

Underbody That part of the faucet covered by the shield, which contains the working members of the faucet.

Vacuum Breaker A device that prevents back siphonage by allowing atmosphere air pressure to the system. A type of backflow preventer.

Vent System (Waste) A pipe or pipes installed to provide a flow of air to or from a waste drainage system to protect trap seals from siphonage and back pressure and to equalize the air pressure within the drainage system.

Vertical Pipe Any pipe or fitting that makes an angle of 45° or less with the vertical.

Waste Holding Tank A liquid-tight tank for the temporary retention of body or liquid waste.

Water Distribution System The potable water piping within or permanently attached to the recreational vehicle.

Wet Vent A vent that also serves as a drain for one or more fixtures.

Waterway Internal chamber where the mixing of the water occurs in a faucet assembly.

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