Maximus' Water Supply System

OVERVIEW

*See system diagram on page 6

- Fresh water capacity currently 50 gallons
- 5gpm demand pressure pump/accumulator with a separate external pump/filter system to use surface water.
- Ability to transfer water between tanks (weight balance)
- RO water purification and storage system for drinking water
- Manifold style distribution system to isolate individual fixtures if leaks develop
- Manifold to fixture piping with 3/8 PEX to eliminate fittings (potential leaks)
- 'Calorifier' style water heater operating from 120V electricity or engine/diesel coolant heater
- Thermostatic mixing valve(s) to deliver constant temperature water
- 'Free' water heating from engine coolant
- Integrated temperature sensing and heating to prevent freezing
    - Insulation and heat tape on all external water piping/tanks
    - Individual temperature sensing and heating of external tanks (3) and equipment (2)
    - Automated water recirculation system to periodically circulate heated water through external piping and into (external) fresh tanks.

LAYOUT

- Water storage tanks (2), demand pump and accumulator are on the back wall of the crew cab.
- The passenger side front cargo compartment is the 'wet bay' and contains purification, pressurized storage and distribution equipment.
- The 'calorifier' (heat exchanger/hot water storage tank) is located under the cab at the passenger side front.

STORAGE

Storing water inside is preferable to outside because it can be protected from low temperatures as well as debris. Giving cabin space for this purpose is undesirable. Weight distribution goals would place it as far forward as possible. The rear seat area of the cab is destined for storage and seems like a good candidate location.

- Robust objective: Build a conformal tank out of fiberglass on the floor of the rear cab to hold about 72 gallons. Section it into two parts side to side. It will have two steps, the deepest being 12" without blocking the door to the cabin. The top of the tank will form a storage deck onto which some storage bin racking could be placed. A channel at the rear of the cab will be formed into which the surface water purification system can be placed. Major challenges are a coating material for

inside the fiberglass tank that would make it drinking water safe. It is also possible to weld it together from HDPE sheets.

- Intermediate objective: Place two roto-molded plastic tanks from Class A Customs on the back wall of the cab. They can be separated enough to permit the cabin door to open. Tanks will be 18 gallon (driver) and 25 gallon (passenger) with a pump compartment under the 18 gallon tank. Tanks are oriented vertically and insulated with ¾" poly-isocyanurate (as is the pump compartment). Insulation is protected by a layer of 2.8mm Luan plywood. Plywood is edged in 1/16" aluminum angle. Tanks are secured to the back of the cab using rivet nuts into the double walled beam below the rear window. Aluminum brackets are bolted to the rivet nuts to lock the tanks side to side and provide ratchet strap anchors points that support a horizontal strap. Water level measurement is by slots in the side of the tank insulation that allow visibility of the water level from the door. An LED light under the tank to illuminate water inside will aid in seeing the water level. Stiffening ribs of 1 x ½" aluminum channel across the tank face at 1/3rd and 2/3^{rds} high.

HEATING

Water is heated and stored in a 20l 'Surecal' calorifier (under the cab below the front passenger seat). Heating can be accomplished in 3 ways using either electricity of the hydronic system;

1) When the engine is running, hot engine coolant can be allowed to circulate through the calorifier if the hydronic system selector switch is set to 'Engine Heat Water'. This allows water heated by engine operation and circulated by the engine coolant pump to be circulated thorough the calorifier's internal coolant heat exchanger, heating the 20l of water to 80C/176F before the engine coolant valves (2) are shut off to prevent overheating the water in the tank.
2) When stationary, the 5kw diesel coolant heater can be started and the hydronic system selector switch set to 'Coolant Heat Water' which allows hot coolant to circulate through the calorifier's heat exchanger, heating water to a maximum of 90C/194F. Normally, the coolant heater will be shut down manually as soon as water temperature reaches ~65C/150F.
3) When stationary and excess battery power is available, a 'water heat' switch in the control center can turn on a 1kw/120V resistance heater inside the calorifier which will heat the tank to 50C/123F. The main inverter must be manually turned on for this option.

An RV style water 'accumulator' is located on the cold supply line to the heater tank to prevent water expansion form over pressurizing the tank. A check valve on the supply side of the accumulator prevents water from expanding in the heater tank from returning into the supply system.

PUMP

A 5GPM demand diaphragm pump is located in an insulated compartment below the 18 gallon tank in a separate enclosure. The pump, accumulator, valves and freeze protection heater are mounted on a removable board inside the compartment that permit disconnection of tank supply hoses (2), enabling the equipment to be removed for service. The internal supply valve (3) system can be draw from either or both tanks or a external source. The external source is anticipated to be a bladder, lying on the rear deck. In the future, a filtration system will also be included to permit a surface water pump to also be

connected. Deliver from the pump can be done to either tank (for consolidation or weight distribution). A pressure gauge in the wet bay reports system pressure.

SOURCE FILTRATION/DISINFECTION

Only potable water will be placed in the tanks. If the source is chlorinated, it will remain. No filtration of 'city water' will be done. The sanitation of the water requires dissolved decontaminants while the water is in storage. Water from a surface source requires a chlorinating compound to be added to the tank(s). A surface source filtration system consisting of a large, 20 micron particulate filter and a 6gpm UV sterilizer are intended but not yet implemented. Since the majority of the water is used for washing, only the portion needed for drinking will be further purified by the RO system.

A residential reverse osmosis water purification unit (ROWPU), located in the wet bay, will process and store 1.2 gallons of water (under pressure) to supply a drinking water faucet at the kitchen sink. The ROWPU system is augmented with a 'permeate pump', powered by the 40 psi demand pump that increases RO processing efficiency and storage pressure. Bypass water from the RO filter is returned to the fresh tank as opposed to down a sanitary sewer in a residential installation.

PIPING & DISTRIBUTION

From tanks, through pumping, heating to distribution manifolds will be ½" PEX (all things 'external'). Inside the wet bay, hot and cold supply lines connect to separate Viega 4 port 'mini-blocs' to distribute water to fixtures. Piping from the distribution manifolds to fixtures will be 3/8" PEX.

RECIRCULAITON

One of my more unique features is that I have a return valve system on all my fixtures that allows the user to fill the hot side water pipe with hot water all the way to the fixture before using it. At each fixture is a valve with a return line to the fresh tank. Operating it momentarily will fill the hot water line with hot water and return the cooled water to the fresh tank. Since fixtures each have a dedicate pipe run from the manifold, each of different length, the amount of time needed to purge the cooled water varies from 5-10 seconds. Running it for too long is not a problem. All that happens is that some of the returned water will be warm.

THERMOSTATIC MIXING VALVE

There are two mixing valves, each with a different purpose. At the calorifier hot outlet, a mixing valve insures that delivery of hot water into the cabin is never more than 52C/125F. This is because the coolant heated water will be VERY hot and could be injurious. At the shower, a mixing valve to allows the temperature to be set and maintained precisely. Along with the recirculation valve, this allows a shower to be taken with completely stable temperature and almost no water waste.

TANK FILL/CITY WATER INLET

A male hose bib in the wet bay serves as the city water inlet. To attach a male hose end, I use a double ended female hose adapter. This allows the connection to the water system to be used as either an inlet (from a potable source) or an outlet (to connect a hose to use outside the camper). There is no check

valve as with a standard RV city water inlet. This requires the user to know that the city water side pressure is higher so the camper pump does not back-feed the city water source. The water pressure gauge is next to the valve so when connecting an external source, water pressure can be confirmed to raise upon connection.

LOW POINT DRAINS

The distribution manifold blocks each have a drain as do each fresh tank.

FREEZE PROTECTION

The primary method of protecting the water system from freezing is keep water in motion regularly when below freezing temperatures are encountered. If this is insufficient, individual secondary systems, using measured temperatures at various locations, activate heating equipment. Heating is available for the water system from either electrical heaters or diesel heated water. Temperatures are measured in the 1) wet bay, 2) pump bay, 3) 18 gallon fresh water tank, 4) the 25 gallon fresh water tank, and 5) hot water tank. There are also several 'incidental' (intentional) heat systems in play. The water pump creates heat as it pumps water. This heat, being released in the small, insulated pump compartment, tends to do most of the heating needed. In warm weather, the compartment actually needs to be ventilated. The diesel coolant heater is located in the wet bay. When it is operating in sub freezing temperatures, it heats the compartment with residual heat (heating is 'lost' from the burner and associate piping.)

PRIMARY:

Since electricity is hard to come by in an RV and even harder in cold weather, the primary source of most of the heating will be from diesel heated water. Much like houses in cold weather climates using a tap left partially on to prevent exposed lines from being static long enough to freeze, I have implemented something similar using my recirculation system. In the wet bay, I have a motorize ball valve that allows heated water from the hot water tank to be 'returned' to the fresh water tanks. This does two things 1) it raising the overall temperature of water in the whole system and 2) it mixes water which may have cooled off in piping with the warmer water in the fresh tanks. The bypass valve is operate by a programmable timer that opens, allowing hot water to flow into both tanks for 30 seconds. To make hot water flow, water is drawn from the water tanks and moved through all of the supply piping. If water in the lines were cooling off, the cooled water will be pushed into the hot water tank and be replaced with warmer water from the fresh tank. This system operates continuously every 30 minutes, when the freeze protection system is turned on. Interval and duration of the recirculation can be changed at the control center.

SECONDARY:

1) Electric air heaters made from CPU cooling heat sinks/fans are located in the wet bay and pump bay. When the freeze protection system is turned on, the fans operate continuously. When heat is needed, the STC-3008 controller turns on either one (pump bay) or 4 (wet bay) 40W/12V cartridge heaters. These are thermostatically operated between ~1C and 4C.

2) 35W/12V silicone strip heaters are placed on the bottom of both water tanks. If the water return system does not provide sufficient heat, they will turn on at 1C and off at 4C, controlled by separate STC-3008 temperature controllers.

3) 120V heat tapes are wrapped around supply and drain pipes. These provide 3W per linear foot of heat. Heat tapes self regulate based on thermo-resistive wire. All heat taped pipes are also insulated with ½" of polyethylene foam. These are turned on manually, either in extreme cold or after a pipe have frozen. This system operates from the always on 800W inverter.

Maximus' Water Supply & Freeze Protection