Whale®
WATER SYSTEMS SPECIALIST

Munster Simms Engineering Ltd., Old Belfast Road, Bangor.BT19 1LT Northern Ireland
Tel: 44(0)1247-270531 Fax: 44(0)1247-466421 Email: sales@whale.ltd.uk http://www.whale.ltd.uk

Ref. No. 162.63

QUICK CONNECT

12-15-22 MM

TECHNICAL DESIGN GUIDE

Whale®
WATER SYSTEMS SPECIALIST

1 INTRODUCTION

The purpose of this guide is to highlight the key operating parameters encountered within the fresh water plumbing systems of 'mobile' units (e.g. leisure marine and RV's). Through a clear understanding of these parameters, best practice design considerations will be outlined which, if adopted, should result in systems which are safe to use and give many years of trouble free service.

2. OPERATING PARAMETERS

Unlike most 'domestic' applications which tend to be open/vented, plumbing systems in 'mobile' units tend to be 'closed' systems. They can also be subjected to physical vibration and stress. It is important therefore to understand the implications of these parameters when designing the plumbing systems.

2.1 Closed Systems

By this we mean the entire plumbing system of necessity tends to be totally sealed. Items such as open header tanks, vent pipes and open vented loops (for practical reasons) tend not to be used and consequently problems associated with pressure build up may occur (Fig. 1).

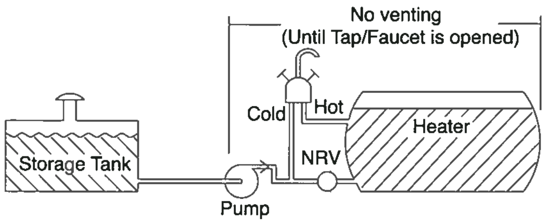


Fig. 1 Simple Closed System

2.2 Pressure

The source of pressure (and flow) in most mobile units is generally understood to be a pump. The pressure generated being controlled to normally no more than 45 p.s.i. (3 bar) via either an integral or remote pressure switch. Alternatively some systems may be connected to city/mains water supplies through a special connector incorporating a pressure regulator. These sources of system pressure are generally well understood and easily predicted. However what may not be fully appreciated is the impact of heating the water within a closed system.

2.2.1. Water Expansion

When water is heated, it expands by approximately 4.5% (by volume) over the temperature range from freezing to boiling. Clearly since water, being a liquid, is incompressible a volume (air gap) should be provided to prevent generation of very high pressures (air being compressible and acting as a spring). Ideally this air gap would be provided for in the water heater itself - Fig.2(a). Alternatively an external expansion vessel can be plumbed into the hot outlet line close to the heater - Fig. 2(b). Failure to allow for thermal expansion can generate extremely high pressures which in fact may only be limited by pressure relief valves or system component failure.

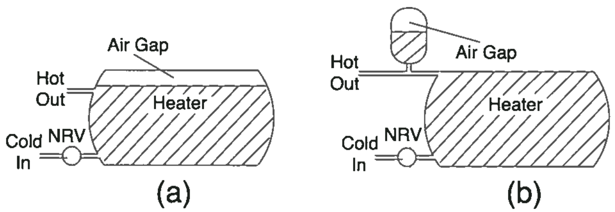


Fig. 2

Careful consideration should be given to the size of this air gap and the table below can be used to calculate the volumetric expansion given the temperature range.

Degrees F(C)	Volume (Units)	Degrees F(C)	Volume (Units)	Degrees F(C)	Volume (Units)	Degrees F(C)	Volume (Units)
39.1(4)	1	86(30)	1.00425	131(55)	1.01423	176(80)	1.02872
50(10)	1.00025	95(35)	1.00586	140(60)	1.01678	185(85)	1.03213
59(15)	1.00083	104(40)	1.00767	149(65)	1.01951	194(90)	1.0357
68(20)	1.00171	113(45)	1.00967	158(70)	1.02241	203(95)	1.03943
77(25)	1.00286	122(50)	1.01186	167(75)	1.02548	212(100)	1.04332

To calculate the appropriate volume the fact that the airgap will be compressed when the system is pressurised must also be considered. This can be estimated using the expression P1 V1 = P2 V2 (assuming constant temperature) (Boyle's law).

Worked Example

Assuming a water heater contains water at ambient temperature of 50ºF(10ºC) which is to be heated to 140ºF (60ºC what size of air gap should be provided assuming the system can be pressurised initially to 45 p.s.i.(3 bar).

From the table:

Water expansion over this temp range is approximately 1.7%.

22.7 ltr. becomes 23.1 ltr (6 US gals becomes 6.102 US gals)
Thus 0.4ltr (0.102 US gals) of an air gap must still remain after the system is pressurised to allow for further expansion due to the temperature increase.

Using $P_1 V_1 = P_2 V_2$ (P = absolute pressure) (V = volume of air gap)

$14.5\ V_1 = 59.5 \times 0.4$	$14.5\ V_1 = 59.5 \times 0.102$
$V_1 = 1.64$ ltr.	$V_1 = 0.42$ gals
Therefore an air gap to accommodate at least 1.64 ltr. should be provided.	Therefore an air gap to accommodate at least 0.42 gals. should be provided.

N.B. Clearly if it were possible to reach higher temperatures then a greater air gap would be required. (Eg. At 185ºF (85ºC) in the above example rather than 140ºF (60ºC)an air gap to accommodate 3.6 ltr (1 US gal) minimum should be allowed for).

2.2.2 Pressure Control

To control the pressure noted above, and to comply with best practice, both primary and fail-safe control is strongly recommended. The following table shows these devices with the recommended settings as appropriate and their location within the plumbing circuit is shown in Fig. 3 below.

PRIMARY CONTROLS		
PRESSURE SWITCH	Controls pumps pressure	45 p.s.i. (3 bar)
PRESSURE REGULATOR	Controls city/mains water pressure	80 p.s.i. (5.5 bar)
EXPANSION VESSEL	Controls water expansion	see 2.2.1
FAIL-SAFE CONTROL		
PRESSURE RELIEF VALVE	Backup for primary controls	87 p.s.i. (6 bar)

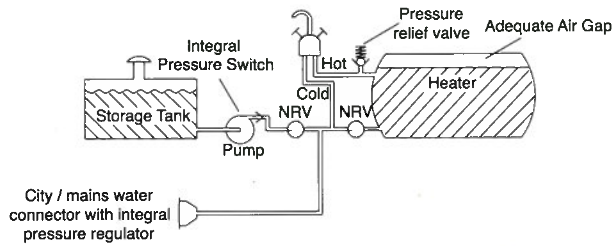


Fig. 3 Schematic Showing Pressure Controls

2.3. Temperature

Water may be heated in mobile units in a variety of ways including:-

- electric heating elements
- diesel water heater
- propane water heater
- hot engine coolant circulating through heat exchanger (calorifier).

2.3.1. Temperature Control

As with pressure control best practice dictates that both primary and fail-safe temperature controls should be fitted.

2.3.2. Heating Electrical Elements

These should be fitted with a control thermostat (which may be adjustable in the range 110ºF - 140ºF(43ºC - 60ºC) and a fail-safe thermostat which would be set at a higher temperature 180ºF(82ºC) to switch off the electrical supply and require a manual reset.

2.3.3. Diesel & Propane Heaters

Most proprietary diesel and propane heaters are fitted with both primary and fail-safe manually resettable controls.

N.B. Before manually resetting any fail-safe device the reason for the fail-safe device being activated should be investigated and put right.

2.3.4. Heat Exchangers

Modern engines run more efficiently at higher temperatures consequently many have pressurised coolant systems which allow for running temperatures close to boiling point ie. 212ºF (100ºC). Clearly if coolant is passed, uncontrolled through a heat exchanger, given time (even with inefficient heat exchangers) the temperature of the heated fresh water will reach unsafe levels.

Two methods of primary control can be used.

(a) Thermostatic Control Valve (Fig.4)

This preferred method of control requires that the valve is inserted into the coolant feed line to the heat exchanger from the engine and the sensing bulb (which is connected to the valve with a length of capillary tube) is attached directly to the upper side of the hot water storage tank. The valve can then be set to cut off hot coolant supply when the heated water reaches the desired temperature.

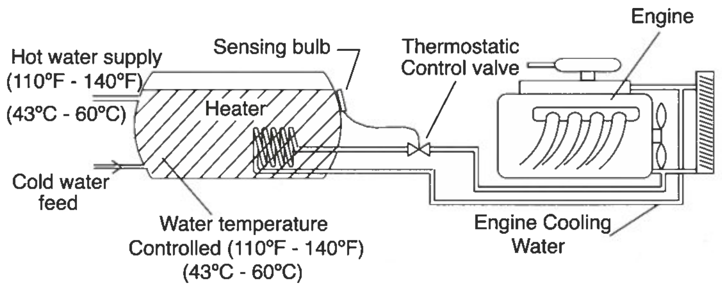


Fig. 4 Arrangement for Thermostatic Control Valve

(b) Thermostatic Mixer Valve (Fig.5)

This device has three ports one (1) of which should be connected directly to the hot water outlet from the heat exchanger. The second port (2) is connected to the cold water supply. Water exiting the third port (3) has been mixed (within the valve) to achieve the control temperature set by the control knob and should be connected to the hot water system.

Clearly with the latter device the temperature of the hot water within the exchanger is very high and referring to section 2.2.1 additional volume to compensate for expansion will be required.

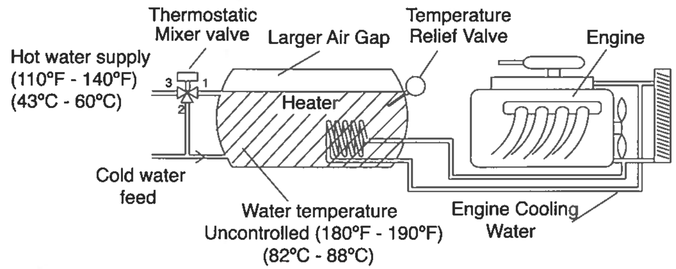


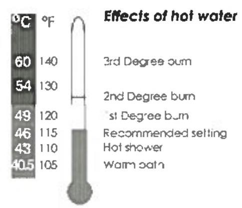
Fig. 5 Arrangement for Thermostatic Mixer Valve

Fail-safe control for both (a) & (b) is effected by a temperature relief valve.

2.3.5. Temperature Settings

Regardless of the water heating method or the control devices used the temperature of the hot water supplied to taps & showers should be controlled in the range of 110ºF - 140ºF (43ºC - 60ºC) with fail-safe set at 180ºF (82ºC).

CAUTION: Ideally the temperature should be set at 115ºF (46ºC) for health and safety reasons higher settings will increase the risk of scald injury. Those at greatest risk of scald injury include children, elderly, disabled and diabetics.



2.4 Fail-safe Devices

The fail-safe devices referred to (pressure and temperature relief valves) earlier may be combination units commonly referred to as P/T (Pressure/Temperature) valves and must not be used as the only/primary method of control.

Where these devices are fitted in boats their discharge ports must have an unrestricted overboard discharge where city mains water regulators are fitted to comply with industry standards and more importantly to eliminate the risk of flooding the boat.

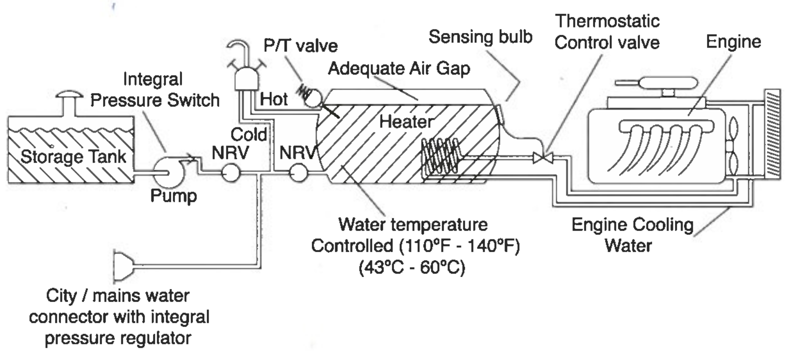


Fig. 6 Recommended arrangement.

3. INSTALLATION

As with operating parameters, differences exist between mobile units and typical 'domestic applications'. Most mobile installations use lower cost plastic tubing and fittings which are lightweight and are fitted in less rigid structures. The following recommendations apply to such installations in mobile units and should be adopted accordingly.

3.1 Connections to Water Heaters

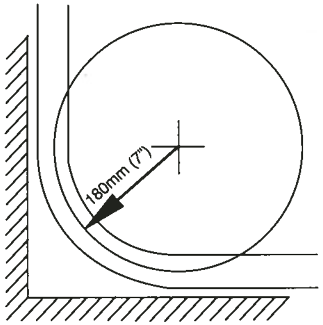
Semi rigid tubing and plastic pipe fittings should not be directly coupled to water heaters and should be kept at a minimum of 350mm (14") remote from the water heater. Connection to the water heater should be effected using metal or metal braided pipe designed for the purpose.

3.2 Bulk Head Connections

Some plastic fittings have quick release mechanisms which are activated by depressing the end of the fittings. These unprotected fittings should not be used up against through - holes in bulk heads where the tubing emerges. The risk here is that as a result of flexing and stresses in the mobile unit the fittings could be pulled against the bulk head activating the release mechanism thus causing a leak. Potential solutions may require special bulk head fittings, collet covers or clips.

3.3 Tube Bend Radii

Care must be exercised when bending semi rigid tubing. Some grades of tubing are more resilient than others and less likely to 'kink' but as a general guideline bend radii should always exceed 7 inches (180 mm).



N.B. With tight bend radii 'kinking' may not at first be apparent but over time and especially in hot water lines 'kinks' may form.

3.4 Tubing Ties

In order to keep tubing runs tidy and organised 'cable ties' and/or clips are frequently used. Care needs to be taken when clipping down the tubing not to apply undue side load to the plumbing connector as some connectors are not designed to cope with this side load and leaks may occur as a result.

3.5 Design Service

Whale not only provide a complete range of quality system components but are happy to answer any technical queries and offer a complete system design service.

For further information contact:

Munster Simms Engineering Ltd.
Old Belfast Road.
Bangor
BT19 1LT
Northern Ireland

Whale Water Systems
Old Belfast Road, Bangor, BT19 1LT. N.Ireland.
tel: +44 (0)28 9127 0531   fax: +44 (0)28 9146 6421
whalepumps.com   info@whalepumps.com

Whale Water Systems Inc
PO Box 1788, 91 Manchester Valley Road,
Manchester Center, VT 05255, USA.
tel: +1 802 367 1091   fax: +1 802 367 1095
whalepumps.com   usasales@whalepumps.com

Warranty

The Whale Water System pipe fittings and tubing are for use within Leisure Marine and Recreational Vehicle portable water systems. The operating conditions of the plumbing system must not exceed those as specified in the guide. Munster Simms Engineering Limited guarantees that the product will correspond with their specification at the time of delivery and it will be free from defects in material and workmanship for 12 months from the date of purchase. No liability will be assumed where third party plumbing components are incorporated into the Whale plumbing system. For specific details please contact Munster Simms Engineering Ltd.

The information contained in this guide has been obtained from sources believed to be reliable and is presented as a useful guide for system designers. However neither the accuracy nor completeness of this guide is guaranteed by Munster Simms Engineering Limited who shall not be responsible for any errors, omissions or damages arising out of use of this guide